Mud Creek

Forest Vegetation/ Silviculture Report

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for:
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Introduction

This report has four primary purposes:

1. To provide background information necessary to evaluate the goals and objectives for the Purpose and Need for action, and to compare the effects of the proposed action on forest vegetation.
2. To describe the existing condition of the forest vegetation and likely trends relating to forest health.
3. To analyze the consistency of the proposed action with the Purpose and Need, Bitterroot Forest Plan, laws, regulations, and policy.
4. To address key issues raised during scoping that are pertinent to forest vegetation management.

The analysis for the forest vegetation resource focuses on how the alternatives would affect the forest species composition, stand density, structure stage, and size class diversity (landscape scale) in the Mud Creek project area and how the proposed action influences the resilience of forest vegetation to future disturbances such as insects, disease, fire, and a warming climate. The Mud Creek project area is prone to and has been impacted by mountain pine beetle, Douglas-fir beetle, Western spruce budworm, and dwarf mistletoe as well as other insects and diseases. Historically fire played a major role in the successional cycle. Fire suppression and past management actions in the 1950s – 1970s have had an impact on the area. This report explains why the Forest Service seeks to treat areas in the Mud Creek project area at this time.

National, Regional, and Forest policies and scientific literature describe and guide us in the species composition, stand density, stand structure, and age class (size class) diversity desired to improve resilience for the forest vegetation. This report includes information to evaluate how well the proposed action will move the vegetation and landscape as a whole toward the desired conditions.

Management direction that is relevant to forest vegetation is evaluated to demonstrate how the proposed action is consistent with the direction in the Forest Plan as well as other policies, regulations, and laws. Also, the report was designed to provide information to evaluate how well the proposed action meets the purpose and need of the project.

Part of the purpose and need for the Mud Creek project is directly related to the forest vegetation resource by improving landscape resilience to disturbances by modifying forest structure, composition, and fuels.

This analysis will focus on the direct, indirect, and cumulative effects of implementing intermediate (commercial and non-commercial) and regeneration treatments to forested stands in the project area. Direct effects are those that occur at the time of treatment, where the treatment takes place; indirect effects are those that take place later in time than the treatment and/or in a different location.

Purpose and Need

This report will focus on the purpose and need for the Mud Creek project directly related to forest vegetation.

- Improve landscape resilience to disturbances (such as insects, diseases, and fire) by modifying forest structure and composition, and fuels.

The departure from historic fire regimes within the project area has created forest stands characterized by high stem densities, hazardous fuels build up, stressed tree condition, and a loss of meadow habitat area and quality. The results are forest stands containing high surface and ladder fuels; stands susceptible to uncharacteristic fire behavior, and stands at high risk to future insect outbreaks. Meadow habitats are experiencing a reduction in size through conifer encroachment and quality through lack of fire necessary to stimulate forbs and grasses.

- There is a need to reduce crown fire hazard potential within the Wildland-Urban Interface, adjacent community protection zone, and low severity fire regimes.
- There is a need to reduce stand densities, increase age class diversity, and favor shade-intolerant species to promote resilience to stressors (e.g. drought, insects, and diseases).
- There is a need to improve habitat and forage quality and quantity for bighorn sheep, mule deer, and elk.

Resource Concerns Related to Forest Vegetation

Issues raised during project scoping were addressed to the extent possible through project design or by design features and mitigations. Issues related to forest vegetation that were addressed through in-depth analysis are summarized below (see PF-SCOPE-037 for full scoping comment considerations).

- In favor of clearcuts to reset succession and allow for greater plant diversity
- Concerns over clearcuts and the potential for stands to regenerate given climate change
- In favor of management to reduce dwarf mistletoe
- In favor of letting insects and disease naturally thin the forest
- Concern for the ponderosa pine old growth stands located at the bottom of Soda Springs Creek and the extreme fire risk due to encroaching Douglas-fir ladder fuels.
- In favor of a thorough field inventory of old growth and do not want to see commercial logging or roads built within these stands, but would approve of understory non-commercial thinning and/or prescribed burning
- In favor of treatment and actions that align with Churchill and Larson’s Individuals Clumps and Openings (ICO) approach to ecological restoration
- Concerns for landscape resilience and would like to see the same management strategy that is applied in the WUI, applied throughout the project area
- Disagrees with treating areas that historically had infrequent mixed and high severity fires, such as steep north-facing slopes and riparian areas
- In favor of site-specific treatments designed through careful site analysis before recommending treatment

Resource Indicators and Measures

Resource indicators and associated metrics are used to quantity change relative to forest vegetation and the proposed action. They are derived from the project purpose, are used to analyze issues raised during internal and external scoping, and are bound by laws, regulations, and policies. Table 1 lists the resource indicators and the unit of measure used to evaluate the impacts of each alternative. All measurements described below are common and universally accepted silvicultural standards that are quantifiable, repeatable, and applicable across forest types and thus are appropriate for use in this analysis.

Table 1. Detailed resource indicators.

Element	Indicator	Measure (quantify if possible)	Addresses/Scale
Forest Resiliency	Species Composition	Early seral species % (acres improved)	Forest Health & Resiliency at the Stand and Landscape Scale
	Stand Density	Trees Per Acre Basal Area (acres improved)	Forest Health & Resiliency at the Stand and Landscape Scale
	Structural Stage	Size Class Distribution (acres per size class)	Landscape Heterogeneity (Resiliency)

Forest Resiliency, the Forest Service defines resilience as "the ability of an ecosystem and its component parts to absorb, or recover from the effects of disturbances through preservation, restoration, or improvement of its essential structures and functions and redundancy of ecological patterns across the landscape." (U.S. Forest Service, 2015) Ecosystems are healthy when their components and processes are functioning properly. A healthy and resilient forest ecosystem will include resilient species composition, stand densities, structures, and a landscape arrangement that meets the multiple resource objectives for this area including fire/fuels, wildlife, aquatics, etc.

Species composition is the percent of a stand made up of different species, this can be defined by the total trees per acre (TPA) and/or basal area (BA) that one species represents as a percent of the total TPA or BA within a stand.

A stand is defined as a contiguous group of trees sufficiently uniform in age class distribution, composition and structure, and growing on a site of sufficiently uniform quality to be a distinguishable unit. (U.S. Forest Service, 2015)

Density is defined by TPA and/or BA. Basal Area is a measure of density where the given area of trees is described by the cross-section (in square feet) of those trees. In stands dominated by larger trees, BA will be used to describe density however, in stands with trees less than five inches in diameter at breast height (DBH), TPA is generally used to describe density. DBH is defined as the diameter of a tree four and one-half feet above the ground, on a per acre basis.

Structural stages are used to describe stand development following disturbance (Oliver & Larson, 1996). Size class is used in this analysis to map and measure the diversity of structural stages, also known as landscape heterogeneity, across the landscape. The size class attribute is derived from the quadratic mean diameter (QMD), which is the diameter of a tree with the average basal area within a stand, measured on a per acre basis.

Methodology

The methods, science, and assumptions that are used for the analysis in this report are noted in relevant sections of the report. This vegetation report incorporates stand, project level, and landscape-level data sets and analysis. General methods and information sources are discussed below.

Information Sources

Landscape Level Data

Region 1 VMap

Region 1 vegetation mapping classification database (VMap) is a remotely sensed existing vegetation database that houses calculated values for lifeform, dominance type, tree size class, and tree canopy cover (Brown et al, 2017). Software is used to break landscapes up into discreet, homogenous polygons and the aforementioned attributes are applied to each polygon using the Region 1 Existing Vegetation Classification System (Barber et al, 2011). This product is updated periodically. The latest version that the Bitterroot National Forest is currently using is from 2016. VMap provides a snapshot of the existing vegetation across the entire planning area to assess conditions at a landscape scale. Airborne imagery data has some limitations and is limited to visible or overstory vegetation data. This tool is relevant for use at mid-level planning and analysis. Fine-scale data will be collected in all proposed treatment units through stand diagnosis during the implementation phase. (See Implementation Plan, Appendix B)

Bitterroot National Forest 2017 Rapid Assessment and Out Year Planning data outputs are derived from VMap base data (U.S. Forest Service, 2017).

Forest Inventory and Analysis data

Forest Inventory and Analysis (FIA) is a system of plots that fall randomly on all ownerships across the United States; measured attributes include species, size, forest health indicators, down woody material information, trees per acre, and habitat type (Bush & Reyes, 2014). Some of these attributes are used to calculate ancillary metrics such as dominance type, canopy cover, basal area per acre, trees per acre, and various insect and disease hazard ratings. FIA data is coarse-scale data and limited to 56 plots in the West Fork geographic area, where the Mud Creek project area resides. (See Bitterroot FIA Information, PF-SILV-002)

Aerial Detection Surveys

Insect and disease aerial detection surveys (ADS) are conducted annually across the majority of the forest using aircraft. Data collected during these survey flights are mapped annually providing a record of insect and disease activity over time. The repeated surveys show trends in insect and disease activity and can help prioritize management actions.

Stand Level Data

Walk-through Diagnosis

This is data collected according to the Forest Service Manual, chapter 2470. The purpose of the diagnosis is to determine existing stand conditions and how these may or may not depart from desired conditions, and whether or not it makes sense to treat now or defer treatment to achieve the desired condition (U.S. Department of Agriculture, 2014). Initial walkthrough surveys were conducted on approximately 4000 acres in the Mud Creek project area in 2018 and 2019. Stand data was uploaded into FSVeg Spatial.

FSVeg/FSVeg Spatial

FSVeg houses field sampled vegetation such as tree species, age, size class, crown ratio, fuel loading information, habitat type, etc. These data are summarized on a per acre or per stand basis and geographically displayed in FSVeg Spatial. Habitat type (Pfister et al, 1977) and fire groups (Fischer and Bradley, 1987) are stored in FSVeg/FSVeg Spatial and field checked during the walkthrough diagnosis. R1 Broad Potential Vegetation Types (PVT) are groupings of habitat types and extrapolated to the project scale in the following analysis. FSVeg is not available for the entire project area. Additional stand data will be collected in all proposed treatment units through stand diagnosis during the implementation phase. (See Implementation Plan, Appendix B)

Activity Data

Forest Service Activity Tracking System (FACTS)

Past activity data is from the Forest Service Activity Tracking System. This system houses information on past harvest, planting, commercial and pre-commercial thinning, burning, fires, and other activities that have taken place in the project area.

Geospatial Information System (GIS) Layers

Various GIS layers were used as sources of information and for spatial analysis including the following:

- FSVEG/VMAP Merge layer is a combined existing vegetation layer where current stand exam data is used in place of VMAP data where it exists to create an existing vegetation layer.
- Landfire Biophysical Setting Fire Groups
- Stand data: Stand delineations and associated data from FSVeg and FACTS.
- Past Activities from FACTS
- Old Growth
- Terraced Plantations
- Forest Plan Management Areas

Spatial and Temporal Context for Effects Analysis

The spatial boundaries for analyzing the direct, indirect, and cumulative effects on vegetation are discussed at the Mud Creek project area scale. The project boundary encompasses 48,523 acres, 46,460 acres of which are Forest Service NFS lands, 1,897 acres of private ownership, and 166 acres of State land. This size of the project area is large enough to capture the effects of treatment to the vegetation resource in terms of changes to species composition, stand density, structure, and size class distribution at the stand level and the landscape scale. Cumulative effects will be analyzed for the adjacent Federal, State, and private lands.

The temporal boundaries for analyzing the direct, indirect, and cumulative effects are approximately 50 years into the future. Due to changes in vegetation conditions over time such as growth, mortality, and natural disturbance processes, vegetation effects beyond 50 years become less reliable. In this analysis, short term effects last 1 to 20 years while long term effects last up to 50 years. Cumulative effects include the direct and indirect effects of the proposed action plus the past, present, and reasonably foreseeable future actions. Current conditions reflect the cumulative effects of past activities.

Affected Environment

Existing Condition/Desired Conditions

The Mud Creek project area is made up of a variety of biophysical settings. Both potential and existing vegetation classifications are used in the analysis and will be used in the future implementation of the proposed action. Potential vegetation classifications are assemblages of habitat types into R1 Broad Potential Vegetation Types (PVT) housed in the FSVeg database while existing vegetation or R1 Cover Type classifications are assemblages of dominance types derived from VMap using the R1 Classification System (Milburn et al, 2015; Barber et al, 2011).

Broad PVTs are derived from habitat types further grouped into potential, near climax, vegetation groups. Potential vegetation is important in understanding the vegetation communities and their response to the natural disturbance processes common to each setting grouped (Habitat Type Grouping Crosswalk, PF-SILV-003). Complete FSVeg data coverage, including habitat types, is unavailable for the project area at this time. Approximately one-third of the project area has habitat type data completed from past stand exams in the 1980s, 1990s, and recently in 2018 and 2019. However, habitat types will be collected as part of the stand diagnosis during the Implementation Phase to aid in selecting the best treatment for each proposed treatment. (See Implementation Plan, Appendix B)

Landfire provides project-wide biophysical settings broken out by fire groups. Western Montana Fire Groups are derived from habitat types (Fischer and Bradley, 1987). The analysis was performed to compare FSVeg data with field verified habitat types in the Mud Creek project area to the Landfire mapped fire groups. Overall 67% of the FSVeg stand data, that is available, aligned with the Landfire biophysical setting data when stratified by R1 Broad PVT categories. This was determined to be suitable for classifying Broad PVTs for the project area at this time. Follow-up data collection will occur in the proposed treatment units during the implementation phase. (See Implementation Plan, Appendix B)

Existing vegetation is classified using R1 Cover Types (Milburn et al, 2015). The Mud Creek project area contains a variety of vegetation cover types or forests that are dominated by one or a mix of tree species. R1 VMap categorizes these dominance types by the species with the greatest abundance of canopy cover, basal area, or trees per acre within an area. Map 1 below displays the existing species with 40% or greater dominance across the project area. Table 1 breaks out the dominance types by acres and percent of the project area.

Map 1: Species Dominance Type

Mud Creek Project Area Existing Vegetation

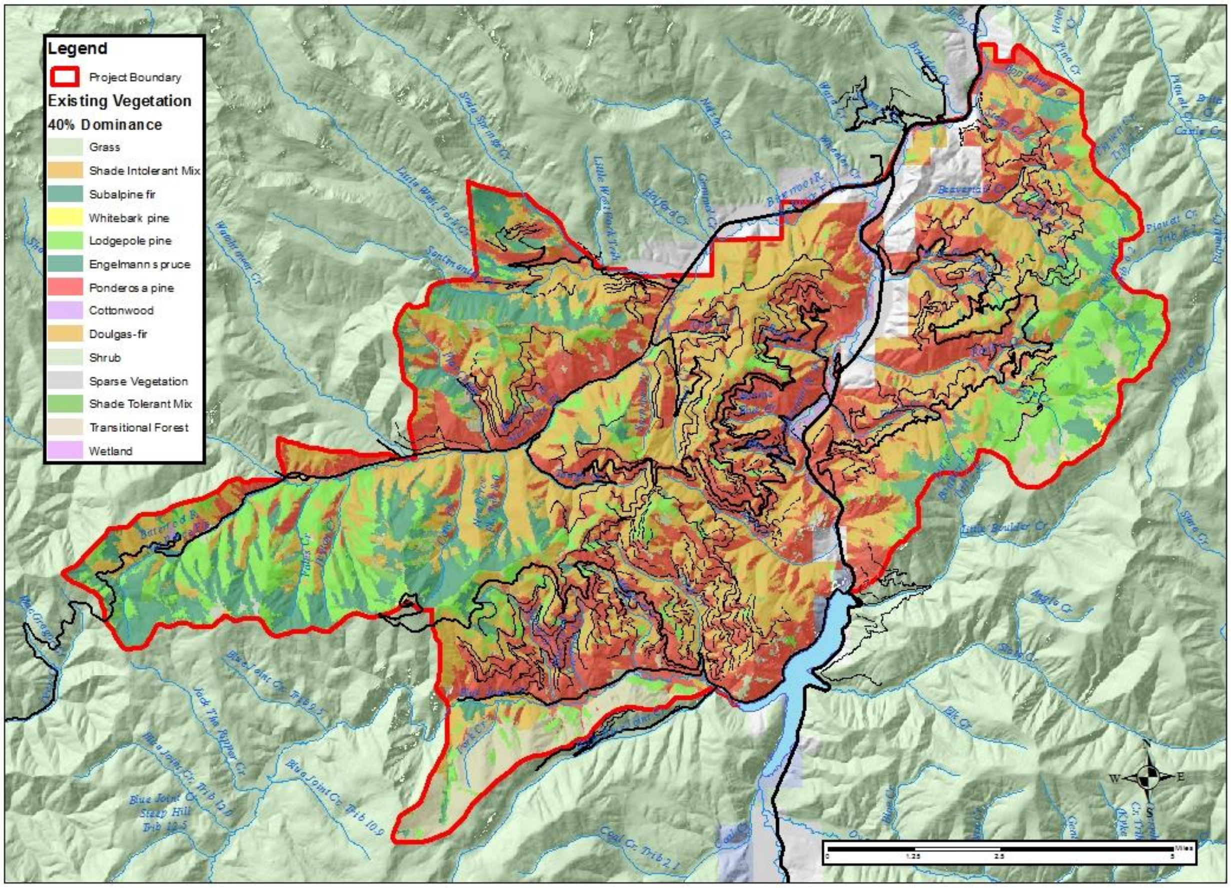


Table 2: Vegetation Dominance Type Breakout for the Mud Creek Project Area

Dominance Type (40%)	Acres	Percent of Analysis Area
Douglas-fir	16399	35%
Ponderosa pine	13442	29%
Lodgepole pine	5930	13%
Subalpine fir	2814	6%
Engelmann spruce	2658	6%
Transitional Forest	1856	4%
Shade Intolerant Mix	1639	4%
Shade Tolerant Mix	756	2%
Grass	412	0.9%
Sparse Vegetation	355	0.6%
Cottonwood	213	0.5%
Shrub	84	0.2%
Whitebark pine	84	0.2%
Wetland/Water	71	0.2%
Total Acres	**46505**	

The Mud Creek project area is made up of primarily two main forest types, warm and dry ponderosa pine and Douglas-fir dominated stands (68%) and cool and moist stands containing a mix of lodgepole pine, Douglas-fir, subalpine fir, and Engelmann spruce (26%). A very small percentage of the project area falls into the high elevation cold forest types containing whitebark pine, subalpine fir, and lodgepole pine (<1%). The warm and moist forest types that contain a mix of the other mentioned species as well as grand fir are small in area, mostly transitory, and can fall into either warm and dry or cool and moist types depending on more specifically defined site conditions.

Forest Types

Warm and Dry Ponderosa pine and Douglas-fir Forest Types

The warm and dry environments include the ponderosa pine, dry Douglas-fir, and the shade intolerant mix dominance types in Map 1. Shade intolerant mix contains a mix of species that are relatively incapable of developing and growing normally in the shade of other species (Barber et al, 2011). In the Mud Creek project area this mix primarily includes ponderosa pine, but can also contain lodgepole pine and Douglas-fir, however, no one species making up 40% or greater of the species composition. The warm and dry forest types make up the largest portion of the project area at 31,480 acres, approximately 68%. The warm and dry vegetation types are often found at elevations below 6000' and on warm and dry southern and western aspects. These forest types are currently a mix of ponderosa pine and Douglas-fir although historically more often dominated by ponderosa pine.

The primary disturbance agents in these forest types are bark beetles and wildfire. Fluctuations in temperature and precipitation strongly influence the frequency, intensity, and size of disturbance processes. Historically wildfire burned at low (primarily) to mixed fire severity with the occasional stand-replacing fire (Arno, 1976; Applegate et al, 1997; and Fischer & Bradley, 1987). Frequent (5-20 year average fire return interval), low-intensity fire created stands of mature open-grown ponderosa pine with productive understory vegetation communities (Arno, 1980; Hessburg and Agee, 2003). These frequent low-intensity fires are what created the conditions responsible for the large legacy ponderosa pine that are found scattered throughout the Mud Creek project area today. Ponderosa pine have thick bark and self-prune lower branches raising base canopy heights. Frequent low-intensity fires favor ponderosa pine thrive while thinner barked species such as young Douglas-fir do not survive. However, with over a century of fire suppression, the species composition is shifting from fire dependent and fire tolerant ponderosa pine to a greater percentage of Douglas-fir, a less fire tolerant species of the two species (Halofsky et al, 2018). Douglas-fir have regenerated in the understory and are competing with ponderosa pine (Figure 1). Due to dense stand conditions, little to no shade intolerant ponderosa pine are able to regenerate in the understory. Stand structure has changed from historically fire maintained open-grown stands containing scattered age class diversity of ponderosa pine to stands with dense Douglas-fir ingrowth creating ladder fuels that carrying

Figure 1: Douglas-fir ingrowth under mature ponderosa pine

fire from the forest floor up through the canopies and into the crowns of the mature ponderosa pine, generating higher fire intensities that are often fatal for all species including ponderosa pine.

Many years of fire suppression and historic logging practices have shifted the distribution of tree size classes and species composition within this forest type to one with more small trees, higher canopy cover, more stories, and more late seral species (Douglas-fir) (Naficy et al, 2010). As more trees grow within the same space, the stand density increases creating competition stress for resources such as sunlight, water, and nutrients from the soil. Mud Creek stands currently have 100 – 200+ square feet of basal area. Historically, these ponderosa pine dominated stands were uneven-aged with horizontally spaced age-classes and much lower stand densities. Regeneration naturally occurred in fire created openings. Shifting fire frequency and intensity to longer intervals with higher intensity can lead to a change in how these ecosystems function (Hessburg et al, 2005; Fitzgerald, 2005). The change in function from how they traditionally worked is not desirable and can lead to widespread ecosystem degradation.

Insects and diseases currently impacting the warm and dry forests in the Mud Creek project area include western spruce budworm, Douglas-fir beetle, and Douglas-fir dwarf mistletoe. All three of these are related to the increase in Douglas-fir due to the lack of fire. Mountain pine beetle was active at epidemic levels in the project area roughly between 2010 and 2013. Mountain pine beetle, as well as western pine beetle, are still present at lower endemic levels. High stand densities due to the lack of fire have led to elevated stress leaving the trees less able to naturally defend themselves against insects and disease. Annosus root disease (P-type) also commonly affects ponderosa pine on the Bitterroot National Forest and is likely present in the Mud Creek project area.

Desired Conditions

The desired condition in these warm and dry forest types is a forest that is resilient to insects, disease, fire, and drought. The following forest condition indicators will improve resiliency at both the landscape and stand-level scale. To improve landscape resiliency, it is necessary to shift stand conditions to a state where fire can burn at low to mixed severity (Hessburg et al, 2005; Larson et al, 2013). At the stand level, improved resiliency requires a shift in species composition toward a greater composition of ponderosa pine (75-90%). Stand structure is more open-grown with horizontally spread out age-classes and size class diversity (Figure 2).

Figure 2: Post-harvest group selection and stand improvement in a ponderosa pine stand. Open grown, age classes horizontally spaced out.

A mosaic of age classes and small openings is desired across the landscape with an emphasis on restoring uneven-aged ponderosa pine stands. Stand densities are at low levels (40-80 BA on average) appropriate for the warm and dry site's carrying capacity and maintained at levels that support a low risk for insects and disease (Randall et al, 2011). Across the landscape, there will be size-class diversity and a mix of successional stages from seedling and saplings to old forest conditions (Lozensky, 1993; Hessburg et al, 1999). Natural openings are present and allow for grass, forb, and shrub diversity. Where found, it is desirable to retain and increase aspen. The desired conditions shall provide forage, cover, and snags for the wildlife species dependent on the warm and dry forests.

Cool Moist mixed conifer forest types

The cool and moist settings primarily include the lodgepole pine, Engelmann spruce, subalpine fir, and mixed mesic conifer (shade tolerant mix) dominance types (see Map 1). Shade tolerant mix refers to a mix of species that can grow and reproduce under the canopy of other species (Barber et al, 2011). In the project area, this mix often includes Douglas-fir, lodgepole pine, Engelmann spruce, and subalpine fir with no one species making up 40% or greater of the species composition. These forest types are found on 12,158 acres, approximately 26% of the project area. Cool and moist vegetation types are typically found at higher elevations and on northern and eastern aspects. The species composition in these areas are often made up of a mix of Douglas-fir, lodgepole pine, Engelmann spruce, and subalpine fir. Lodgepole pine stands in the Mud Creek project area are rarely pure lodgepole pine yet are heavily dominated by lodgepole pine. The majority of the lodgepole pine-dominated stands in the project area are intermixed among the other cool and moist stands. For this reason, lodgepole pine is included in the cool moist forest types for this analysis however it also grows at high elevations in Cold forest types within the project area.

Historic fire return intervals in these stands were less frequent (35-100 years on average and >120 years on the wetter sites) and vary in fire intensity from low to high intensity (Fisher & Bradley, 1987; Arno et al, 2000). These tree species are less fire tolerant than the warm and dry species with some species displaying little to no fire tolerance and naturally experience high levels of mortality or stand replacing fire. Over time, species composition in these stands have shifted from Douglas-fir and lodgepole pine dominance to a higher component of subalpine fir and grand fir at present. Stand densities increase as more shade tolerant trees continue to regenerate on site leading to dense multi-storied stands of shade tolerant species (Figure 3). While these sites are often wetter and naturally capable of supporting more trees, stand densities have continued to increase leading to conditions favorable for insects and disease that thrive in multistoried conditions. Fewer fires have led to a more homogenous forest with less diversity in structural stages, size-classes across the landscape. Without the varied patch size and patterns historically created by fire across the landscape, wildfires are burning with greater intensity over larger areas, and insects and diseases are able to spread further with the increase in older and denser stands (Hessburg et al, 2005).

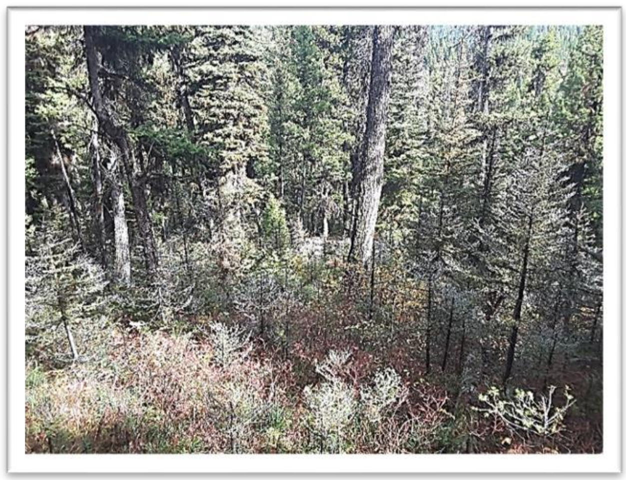


Figure 3: Mixed conifer stand experiencing western spruce budworm defoliation

Desired Conditions

The desired condition is a landscape resilient to insects, disease, and fire. In cool and moist forest types, it is important to restore patch and patterns historically found on the landscape (Hardy et al, 2000) (Hessburg et al, 1999). Where feasible, it is desirable to allow fire to play its natural disturbance role to provide a mosaic of low intensity to stand replacing disturbance patterns and successional stages.

Lodgepole pine patch size, based on a study on the Bitterroot National Forest and the Interior Columbia Basin Ecosystem Management Project, found that current mean patch size ranges from 5 - 66 acres while historic patch sizes range from 34 – 118 acres. “The patch size coefficient of variation was much larger than the mean patch size indicating the wide variation of fire mosaics common on the Bitterroot landscape.” (Hardy et al, 2000) The patch size coefficient of variation historically ranged from 144 – 340 acres showing there was variability in patch size following disturbance. The maximum percent of the landscape occupied by one patch (landscape patch index) was found to be approximately 14%. For the Mud Creek project area, this calculates to the largest historic patch size is estimated at 6,510 acres. (Hardy et al, 2000)

Species composition would include more early seral species including lodgepole pine where present. While Douglas-fir is encroaching in the warm and dry forest types due to the lack of fire, it is a desirable and more fire tolerant species in the cool and moist forests (Figure 4). Stand structure shall be primarily even-aged to reduce the spread of insects and disease however a mix of multistoried stands are desired to provide habitat diversity based on-site and species composition. A variety of structural stages and size classes are desired, spread out across the landscape (Lozensky, 1993; Hessburg et al, 1999). It is desired to increase patch size based on the guidelines from Hardy et al (2000). Stand density varies based on site conditions. Where found, it is desirable to retain and increase aspen. The desired conditions shall be designed to provide forage, cover, and snags for the wildlife species dependent on cool and moist forest habitats.

Figure 4: Post-harvest shelterwood cut in a Douglas-fir stand. Photo is immediately following harvest. Residual trees will provide seed and shelter for a second age class in the future.

Cold forest types

Cold forest types including a species mix of whitebark pine, lodgepole pine, and subalpine fir make up less than 1% of the Mud Creek project area. Whitebark pine rarely appears as 40% dominant in the cover type mapping in the project area and therefore only 84 acres are identified but other queries show the species is present and at risk to insect, disease, or wildfire on approximately 187 acres. In the project area, individual whitebark pine can be found at lower elevations but the species becomes more well established above 7000 feet in elevation. Whitepark pine is considered both a keystone species and a foundation species for its ability to capture snow, regulate snowmelt, reduce erosion, store carbon and provide large nutritious seeds for a food source for wildlife including grizzly bears. Whitebark pine are declining throughout their range due to past mountain pine beetle outbreaks, fire exclusion increasing competition from shade tolerant species, and the introduced pathogen which causes the disease white pine blister rust. (Keane et al, 2012)

In the project area, many mature whitebark pines have died due to past mountain pine beetle attacks. Pole and sapling sized whitebark pine are present but are experiencing crowding from subalpine fir and lodgepole pine. Whitepine blister rust has led to bole and stem cankers and eventually the death of some individuals. Without fire, whitebark pine is unable to regenerate and compete with subalpine fir and lodgepole pine. The lodgepole pine in the cold forests has experience high levels of mortality due to mountain pine beetle. This has also lead to an increase in dead and down fuels. Additionally, the subalpine fir at high elevations is experiencing heavy levels of defoliation and mortality due to western spruce budworm and western balsam bark beetle.

Desired Conditions

The desired conditions in cold forests include an increase in whitebark pine species composition, low stand densities without direct competing vegetation, minimal canopy layers, or horizontally stratified age-classes and openings to create nutcracker caching opportunities. Priority must be taken to emulate fire's historic effects on the landscape to create conditions so the whitebark pine species can persist into the future. The primary objectives in restoration treatments are to (1) mimic some historical disturbance process, mainly wildland fire, (2) facilitate whitebark pine regeneration and cone production, and (3) create optimum nutcracker caching habitat (Keane et al, 2012). Where openings occur, planting blister rust resistant seedlings are desired to ensure reaeration establishment and desirable genetics (Schwandt et al, 2013). The desired conditions will provide forage, cover, and snags for the wildlife species dependent on cold forest habitats.

Old Growth Existing Condition

Site-Specific Forest Plan Amendment

A site-specific, project level, Forest Plan amendment is recommended to meet the Mud Creek project purpose and need to improve landscape resilience to disturbances (such as insects, diseases, and fire). Additionally, the amendment is needed to achieve the goals and objectives provided in the Forest Plan and the 2012 Planning Rule, to maintain habitat and vegetative diversity, and restore key characteristics associated with terrestrial ecosystems. The 1987 Bitterroot Forest Plan definition of old growth offers a "one size fits all" definition and fails to adequately define old growth across a variety of local site conditions and fails to provide criteria that are measurable and repeatable.

"A forest stand with 15 trees per acre greater than 20 inches dbh (6 inches in lodgepole pine) and canopy closure that is 75 percent of site potential. The stand is uneven-aged or multistoried. There should be 1.5 snags per acre greater than 6 inches dbh; 0.5 snags per acre greater than 20 inches; and 25 tons per acre of down material greater than 6 inches diameter. Heart rot and broken tops in large trees are common and mosses and lichens are present." (Bitterroot Forest Plan. U.S. Forest Service, 1987)

The amendment for old growth instead proposes to use the stand characteristics to define and measure old growth using the quantitative and qualitative factors found in Old-Growth Forest Types of the Northern Region by Green et al. 1992, errata corrected 2011. Green et al. represents the Region's (Northern Region of the U.S. Forest Service, Region 1) best available scientific information to define old growth. The old growth criteria are specific to forest type and habitat type group. Key measurable attributes include age, numbers (stand density), and diameter of the old tree component within the stand. Minimum thresholds have been established for these attributes for each habitat type group. Old growth associated characteristics are also defined such as probabilities of coarse woody debris, the number of canopy layers, and the number of snags over 9 inches diameter at breast height. These site-specific criteria make this science a better measure to evaluate old growth. The site-specific Forest Plan old growth amendment can be found in Appendix D).

The amendment also proposes a site-specific modification to the Bitterroot Forest Plan (1987) management area standards for old growth, removing the requirement that "old growth stands should be 40 acres and larger". The modification would allow stands to be managed for old growth at any size. A stand represents a relatively uniform forest plant community that occupies a specific area of land. Stands are identified as areas with relatively uniform species composition, structure, age, size class, and site conditions. Any form of disturbance that resets the successional process can create new stands, with new boundaries, over time. Regardless of size, a stand can offer habitat and vegetation diversity and is important in restoring terrestrial ecosystems. Maintaining key old growth characteristics in stands of any size supports the Forest Plan objectives to maintain old growth. (See Site-Specific Forest Plan Amendments, Appendix D)

Existing Condition

Old growth, as defined by Green et al, (1992, errata corrected 2011), occurs in the Mud Creek project area. Old growth is classified based on site potential stratified into habitat type groups (See Habitat Type Grouping Crosswalk, PF-SILV-003). Based on the National definition, "old growth forests are considered ecosystems that are distinguished by old trees and related structural attributes. They encompass the later stages of stand development that typically differ from earlier stages in characteristics such as tree age, tree size, number of large trees per acre, and basal area. In addition, attributes such as decadence, dead trees, the number of canopy layers and canopy gaps are important but more difficult to describe because of high variability." (Green et al, 2011). Old growth is measured at the stand level using habitat type, large tree age, diameter at breast height (DBH), and basal area.

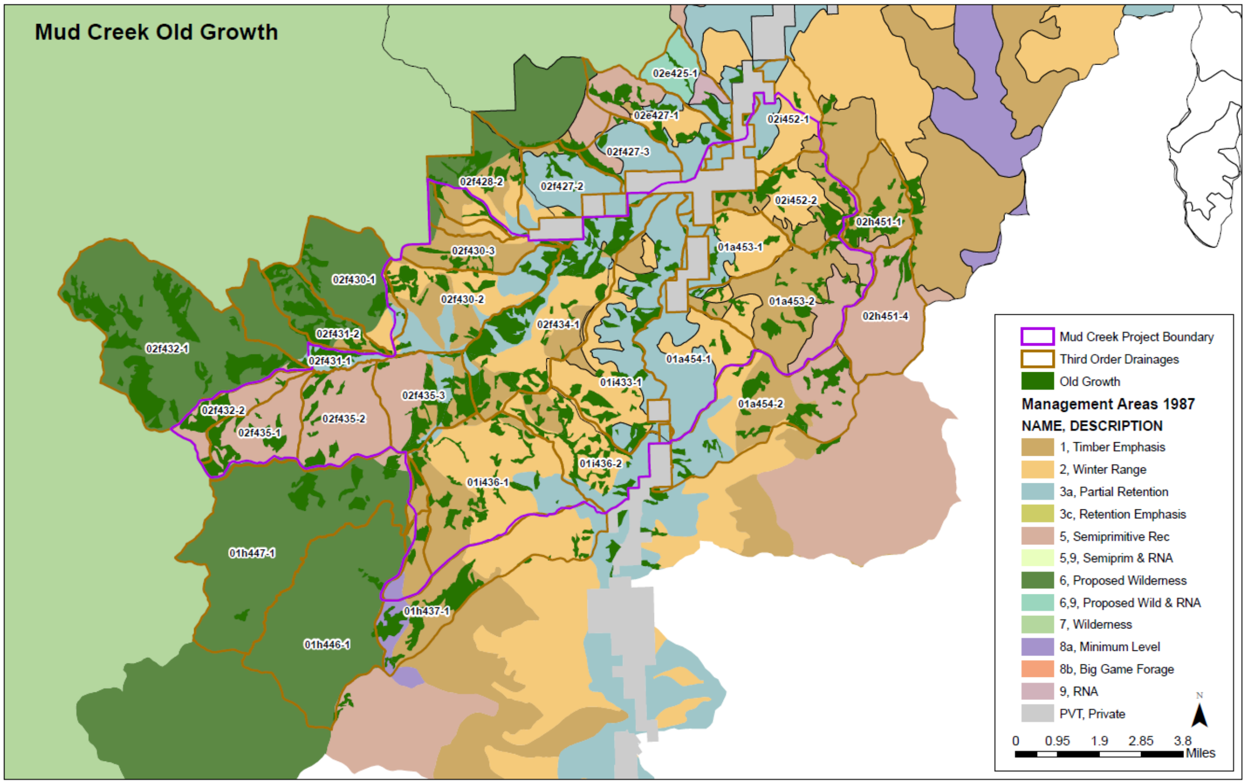
Past Common Stand Exams stored in the FSVeg database as well as the Forest's historic aerial photo interpreted old growth GIS layer was used to determine the current old growth status for analysis for the watersheds within the Mud Creek project. Approximately 8,512 acres (18% of the project area) of old growth are currently mapped within the Mud Creek project area. Of these acres, 1,400 acres have been field verified as old growth through on-the-ground, statistically sound Common Stand Exams and 7,113 acres are mapped in a historic old growth layer identified through aerial phone interpretation. See Map 2 below for locations. Old growth status will be validated during the stand diagnosis within proposed treatment units during the implementation phase.

Figure 5: Large legacy ponderosa pine with a dense understory of Douglas-fir that is infected with dwarf mistletoe and is experiencing western spruce budworm defoliation

As described in the warm and dry forest type section above, frequent low intensity fire was the primary disturbance process responsible for creating conditions suitable for ponderosa pine old growth, the most commonly found old growth species in the Mud Creek project area. Other old growth stands dominated by Douglas-fir or others can be found in the project area, however, the general discussion to follow will focus on the most common old growth stand characteristics. These old growth stands often have a patchy distribution of larger diameter, old trees with canopy cover on approximately one-third of the stand while the other two-thirds of the stand contains canopy openings where understory vegetation and associated wildlife thrive in this open and clumpy environment (Kaufmann et al, 2007). The scattered legacy ponderosa pine found in the project area are distributed in clumps and scattered individuals. Many of these stands have a dense understory of

Douglas-fir that has regenerated under them, often this Douglas-fir is suppressed with large witches' brooms as a result of dwarf mistletoe infection (Figure 5). Past management practices often removed the trees with the greatest value in these stands leaving behind the poorly formed Douglas-fir with defects. This form of high-grading left the trees with disease, physical damage, and poor genetics on site to populate the next age-class. However, past management actions did retain some of the biggest legacy ponderosa pine. Other stands that have not had past timber harvest but have experienced a century of fire exclusion, have high stand densities with multiple age-classes and size classes of Douglas-fir growing among the legacy pines (Arno et al, 1995). When cored, with an increment borer, many of these trees contain some degree of heart rot in the center but are estimated between 200 and 400 years old.

Map 2: Mud Creek Mapped Old Growth by Third Order Drainage



Historically these old growth ponderosa pine grew in uneven-aged stands. Ponderosa pine is a shade-intolerant species meaning it cannot regenerate in the shade of other trees. It is also fire adapted and fire dependent requiring openings to regenerate a new age class (Fiedler et al, 2007; Arno & Fiedler, 2005). Current stand densities in the project area preclude the regeneration of ponderosa pine needed to recruit new trees for the future. Periodic regeneration is essential to sustain all stands including old growth. Many stands within the Mud Creek project have little to no natural ponderosa pine regeneration present in untreated areas.

Climatic changes plus higher stand densities have increased competition for water, nutrients, and sunlight causing increased tree stress. Stress weakened trees are at greater risk for insects plus high densities offer greater opportunity for the spread of insects and disease. In general, if conditions continue on the same trajectory, there will continue to be a decline in old growth in the frequent fire ecosystem found in the Mud Creek project. The old trees are dying and the stands are at higher vulnerability to insects, disease and fire. Greater densities and canopy cover have lower plant diversity, forage quantity, and quality (Keane et al, 2002).

Desired Conditions

The desired condition in old growth ecosystems depends on the habitat type and old growth group specific to each stand. Desired conditions will be based on Green et al (1992, errata corrected 2011) old growth criteria. In general, it is desired to retain the old growth status for stands that meet the criteria. The amount of desired old growth is based on the requirements in the Bitterroot Forest Plan (U.S. Forest Service, 1987) Forest Plan Amendment (Appendix D). Within old growth stands, it is desired to restore function and process while reducing the risk of stand replacing wildfire and the spread of insects and disease. See the desired conditions for warm and dry, cool and moist, and cold forest types. Detailed desired conditions are site-specific. One example of a desired old growth condition in a warm and dry forest would be an open-grown, fire-maintained ponderosa pine stand (Figure 6).

Figure 6: Post-harvest Improvement Cut in an old growth ponderosa pine stand.

Terraced Plantations – Existing Conditions

The Mud Creek project area contains 79 terraced plantations ranging in size from 1 acre to 130 acres and totals roughly 1,645 acres. The majority of the terraces were planted with ponderosa pine in the 1960s and 1970s. The terraces were intended to reduce site competition for planted seedlings, collect more water on steep slopes, and allow more efficient machine-planting. In a study comparing terraced plots to non-terraced plots, Zlatnik (1996) found that there was some evidence of soil erosion on the terrace benches in the form of higher silt content. Understory vegetation biomass was significantly lower on terraced sites yet soil characteristics differed little between the terraced and non-terraced sites. The study showed significantly higher tree volume, both per acre and per tree on the study sites on the West Fork District. Given none of the soil factors evaluated in this study provided a sufficient explanation for the observed differences in site productivity and tree regeneration, plant available water may be the primary factor influencing higher tree volume and seedling establishment on the terraces sites.

A sample of terraced plantations within the project area have been visited by the Soils Scientist and Silviculturist. Stand health, tree size, stand density, and soil conditions varies greatly across the terraces reviewed in the field. Terraces are located on a wide range of aspects, elevations, and slopes. Many stands have experienced pockets of mountain pine beetle mortality and now have concentrations of dead standing and down trees. In other areas, the trees appear to be doing well although stand densities are high and stands have moderate to high mountain pine beetle hazard rating. Moisture deficit appears to be the strongest correlation to stand health and soil conditions.

Figure 7: Terraced Plantation in Mud Creek

Figure 8: Terraced Plantation in Took Creek

Desired Condition

The desired condition for the terraced plantations will depend on site conditions and location. The ponderosa pine terraces will be primarily managed for warm and dry forest desired conditions. However, some ponderosa pine plantations were planted at high elevations and aspects not naturally associated with ponderosa pine dominated stands. In these cases, the plantation will be managed for forest health and a shift to a natural species composition over time. The few terraces that were planted to Douglas-fir or retained a large species component of Douglas-fir residual trees, will be managed for either warm and dry or cool and moist forest desired conditions based on location. Additionally, desired conditions and treatment options will vary based on historical preservation, soil conditions (see Soils report, PF-SOIL-001), fire and fuels concerns (see Fire and Fuels report, PF-FIRE-001), and treatment feasibility based on slope and equipment capabilities.

Existing Vegetation Condition

As mapped (Map 1) and described above, warm and dry forest types dominate the project area by 68%. However, Douglas-fir is currently the most dominant species in the project area followed by ponderosa pine, then lodgepole pine (Figure 9). Landscape heterogeneity can be measured through a variety of forest characteristics. In this analysis, size class is used to measure structural stage diversity also known as landscape heterogeneity when analyzed at the project or landscape scale.

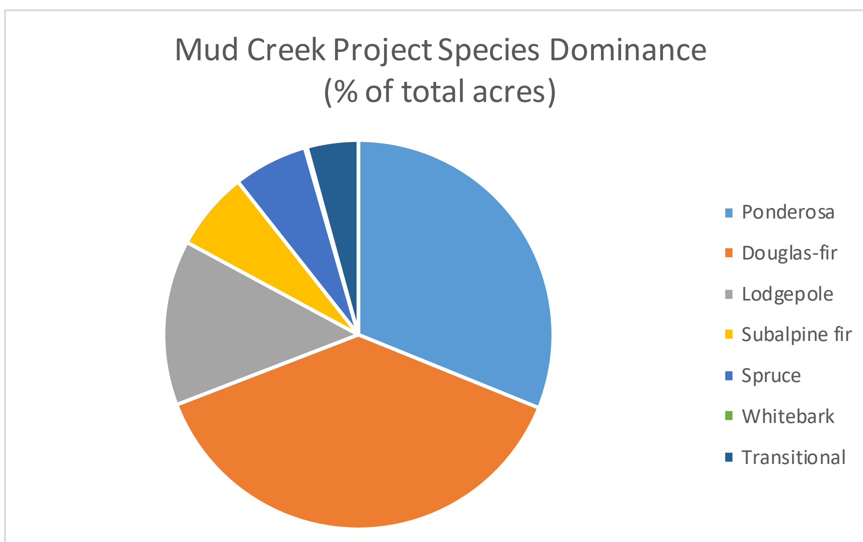


Figure 9: Mud Creek species dominance breakout

As displayed in Figure 10, approximately 68% of the project area has an average size class between 10 to 14.9" DBH. There is also an overall lack of diversity in size class in the Mud Creek project area when compared to more natural conditions found in Losenky's research (1993). See Table 3 located in the Departure from Early-settlement/Natural Conditions section.

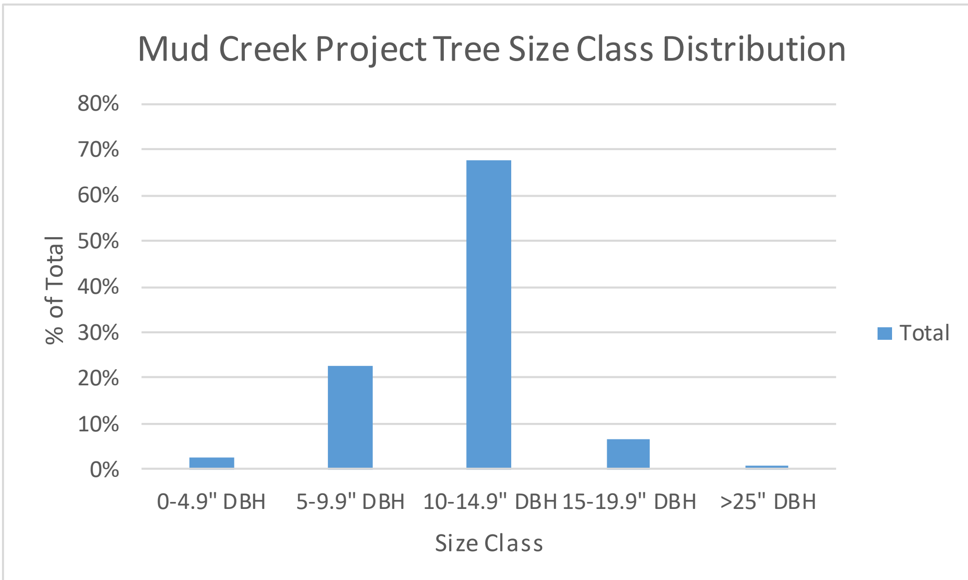


Figure 10: Tree Size Class Distribution

In 2017 the Bitterroot National Forest performed a Rapid Assessment to help prioritize out year planning efforts (U.S. Forest Service, 2017). The Rapid Assessment process used modeling and VMap existing vegetation data. Queries were written to ask the data where there were vegetation concerns. The following silviculture queries were written to identify issues at the mid-scale level for planning purposes.

- Where do we have shade tolerant species encroaching or outcompeting ponderosa pine?
- Where are ponderosa pine and lodgepole pine at risk of density related mortality?
- Where do we have stands at risk of insect-related mortality from the following insects; western spruce budworm, Douglas-fir beetle, or mountain pine beetle?
- Where are we at risk of losing existing stands of whitebark pine?

The following data were extrapolated for the Mud Creek project area. The analysis was performed to determine how the areas of concern highlighted by the Rapid Assessment queries intersected the dominant forest types and the tree size classes within each dominance type. Figure 11 displays the dominance types and size classes at the greatest risk for insect damage based on existing stand conditions. Douglas-fir, ponderosa pine, and lodgepole pine, the 3 main forest cover types in the project area, all show significant acres at risk in the queries performed. Similar to Figure 10, the majority of the stands at risk are in the larger 10.0 – 14.9" DBH size class, the most common size class throughout the project area.

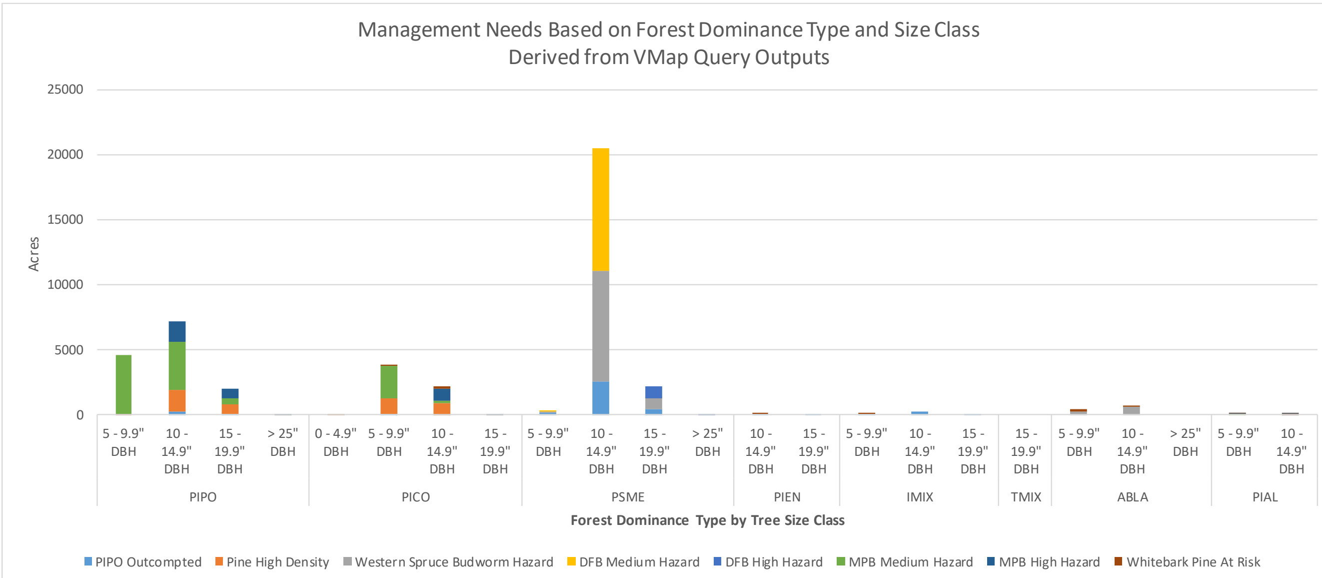


Figure 11: Vegetation Priorities by Dominance Type and Tree Size Classes.

(PIPO – Ponderosa pine, PICO – lodgepole pine, PSME – Douglas-fir, PIEN – Engelmann spruce, IMIX – shade intolerant species mix, TMIX – shade tolerant species mix, ABLA – subalpine fir, and PIAL – whitebark pine)

In summary, Douglas-fir is the primary species dominating the Mud Creek project area, an area that is 68% warm and dry forest types. This is a concern because these forests were historically dominated by ponderosa pine and were most commonly maintained by fire. The project area has become homogeneous with very little size class diversity across the landscape. The mature size class, 10 -14.9" DBH trees, dominates the landscape by 68%. This is a concern because size class continuity at a large scale such as the Mud Creek project area affects the ability for fire, insects, and disease to spread with ease across the landscape. The existing size class distribution is a shift from the greater structural stage and size class diversity found during early-settlement times. The following sections will address the natural disturbances and processes, the existing condition's departure from early-settlement conditions, the concerns and need for restoration.

Natural Disturbance and Processes

The existing condition in the Mud Creek project area was shaped by biotic and abiotic factors, natural disturbances, ecological processes, and human influences. It is important to understand the role these factors have had on the landscape to determine the desired future condition and analyze the effects of the alternatives.

Natural disturbances such as climate variability, fire events, insects and disease plus mankind, all shaped the environment. Native Americans were the first to manage the forest using fire to improve travel corridors, forage, game habitat, and native plant food sources. This burning primarily impacted the lower valley bottoms and foothills. Before the 20th century and European settlement, natural fires burned regularly in the warm and dry forests controlling the amount of regeneration, promoting fire-tolerant species (primarily ponderosa pine and mature Douglas-fir), maintaining open-grown forests, reducing fuels, and decreasing the impacts of insects and diseases (Arno, 1976). More recently, the local environment has been shaped by Forest Service management practices, such as timber sale activity and fire suppression.

Climate and Carbon

The climate is changing, "global climate models project that the Earth's current warming trend will continue throughout the 21st century in the Northern Rockies. Compared to observed historical temperature, average warming across the five Northern Rockies Adaptation Partnership (NRAP) subregions is projected to be about 4 to 5 °F by 2050, depending on greenhouse gas emissions. Precipitation may increase slightly in the winter, although the magnitude is uncertain" (Halofsky et al, 2018).

Halofsky et al (2018) states, "Increasing air temperature, through its influence on soil moisture, is expected to cause gradual changes in the abundance and distribution of tree, shrub, and grass species throughout the Northern Rockies, with more drought-tolerant species becoming more competitive. Ecological disturbance, including wildfire and insect outbreaks, will be the primary facilitator of vegetation change, and future forest landscapes may be dominated by younger age classes and smaller trees. High-elevation forests will be especially vulnerable if disturbance frequency increases significantly." Historical ecology becomes ever more important for informing managers about environmental dynamics and ecosystem response to change. Millar advocates for an integrated ecological approach that includes enhancing resistance to climate change, promoting resilience to change, and enabling ecosystems to respond to change. (Millar et al, 2007)

One of the most common approaches to managing for the unknown is to manage for resiliency. "Resilient forests are those that not only accommodate gradual changes related to climate but tend to return toward a prior condition after disturbance either naturally or with management assistance." (Millar et al, 2007). Halofasky et al recommend most strategies for conserving native systems focus on increasing resilience to chronic low soil moisture, primarily drought, and low snowpack, and to more frequent and extensive disturbances including wildfire and insects. "These strategies generally include managing landscapes to reduce the severity and patch size of disturbances, encouraging fire to play a more natural role, and protecting refugia where fire-sensitive species can persist. Increasing species, genetic, and landscape diversity (spatial pattern, structure) is an important "hedge your bets" strategy that will reduce the risk of major loss of forest cover. Adaptation tactics include using silvicultural prescriptions (especially stand density management) and fuel treatments to reduce fuel continuity, reducing populations of nonnative species, potentially using multiple genotypes in reforestation, and revising grazing policies and practices. Rare and disjunct species and communities (e.g., whitebark pine, quaking aspen) require adaptation strategies and tactics focused on encouraging regeneration, preventing damage from disturbance, and establishing refugia." (Halofsky et al, 2018).

Homogenous landscapes with a greater proportion of vulnerable species and age classes, and/or greater connectivity (few barriers to spread of wildfire, insects, or pathogens) are less resistant to climate changes and disturbance interactions, and may demonstrate loss of ecological resilience; i.e., inability to recover from disturbances (Leohman et al, 2016). Due to a century of fire suppression efforts, the Mud Creek project area has become more homogenous as described above in Figures 10 and 11. The landscape contains less diversity in age-classes, greater connectivity increasing the ease of spread for fire and insects, greater stand densities, and a shift in species composition (Figure 9) that has decreased the areas resilience to disturbances such as insects, disease, fire, and climatic changes.

The importance of carbon storage capacity of the world's forest is tied to their role globally in removing the atmospheric carbon. Meaningful and relevant conclusions on the effects of a relatively minor land management activities such as the Mud Creek project on global greenhouse gas emissions or global climate change is neither possible nor warranted.

Carbon storage gains and losses in the Northern Region (R1) are strongly tied to the history of fire and fire suppression in addition to past timber harvest. Wildfire is the main disturbance resulting in the reduction of carbon stocks. Across the Region, forests are becoming older with less age class diversity. Carbon stores are declining due to aging forests and a greater percentage of the landscape in the older, less productive, slower growing, age classes. In addition to aging forests, climate variability and recent warming trends have negatively affected carbon stocks. The Northern Rockies is experiencing increases in large wildfires that burn longer, as well as longer fire seasons; much of this is due to warming temperatures and droughts (Westerling et al, 2006). Over the past few decades, severe bark beetle outbreaks have caused widespread tree mortality, reducing forest carbon uptake and increasing future emissions from the decomposition of killed trees (Kurz et al, 2008; Birdsey et al, 2019)

Birdsey and others (2019) performed an assessment, expanding on previous assessments, of baseline carbon (C) stocks across individual national forests and at the regional scale, assessing how stocks at those scales are affected by factors such as timber harvesting, natural disturbances, land-use change, climate variability, increasing atmospheric carbon dioxide (CO_2) concentrations, and nitrogen (N) deposition. The results of this assessment generally show that Forests have gone from being carbon sinks to carbon sources. The decline in carbon stores is the result of fire suppression leading to aging forests that are burning at greater intensities over larger areas. The results show the Forests acting as a carbon sink in the 1950s to 1980s when the forests were younger and more productive. As forests aged and productivity declined, carbon stores declined. Meanwhile, widespread disturbances and low rates of regeneration have led to an increase in carbon emissions with the forests becoming a source of emissions rather than a carbon sink. In Figure 12 below, it is clear that fire is the biggest carbon source on the Bitterroot National Forest. Management, including timber harvest, with the objective to improve landscape resilience to fire, insects, disease, and establish new and productive age-classes, is desired to improve carbon stores on National Forest lands. See the Carbon Assessment for additional information (PF-CLIMATE-001)

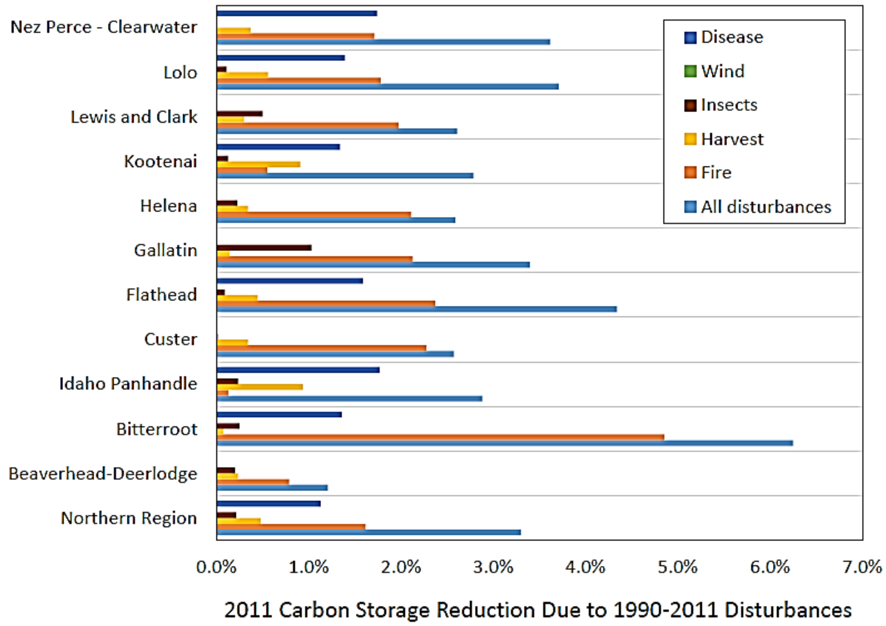


Figure 12: Carbon stock reduction in 2011 due to disturbances occurring from 1990 through 2010, by each national forest and for all national forests in the Northern Region. Percent reduction represents how much nonsoil carbon was lost from the baseline forest inventory carbon stock estimates. (Figure from Birdsey et al, 2019)

Fire

The forests we know today were shaped by fire or more recently, the lack of fire. Arno and Fielder (2005) state in Mimicking Nature's Fire, "findings suggested that historically perhaps 75 percent of western forests experienced fires that killed some trees while others survived. Most of the remaining 25 percent of forests showed evidence of ancient fires that killed nearly all of the trees and led to the establishment of the existing stands". However, following the 1910 fires, fire suppression efforts ramped up and a new policy was set in place to put all fires out by 10 AM the following morning in 1935. With fire suppression, dense forest structures have developed homogenous and continuous horizontal and vertical stand structures dramatically altering forest health, species composition, and how wildfire now burns compared to how fires historically burned (Graham et al, 2004; Peterson et al, 2005). This is readily apparent throughout the Mud Creek project area with the majority of the project area currently experiencing stressors related to high stand densities, impacts from insects, and diseases. A large percent of the project area contains moderate to high hazard ratings for future insect activity based on the R1 Forest Insect Hazard Rating System criterion (Randall et al, 2011) due to changing stand conditions and the lack of fire as a natural disturbance process over time. The majority of the project area has been unaffected by wildfire dating back to the 1880s. Numerous small fires less than 5 acres in size have occurred and were suppressed over the years. Two wildfires that have burned greater than 1000 acres in size have burned along the outer perimeter of the project area since 2000.

Insects and Disease

The following section will discuss the primary insects and diseases found in the Mud Creek project area and some management guidelines for reducing the impacts of these native and non-native disturbances.

Insects

In 2017, the Bitterroot National Forest completed a Rapid Assessment for Out Year Planning efforts for the Forest (U.S. Forest Service, 2017). Through this process, vegetation queries were written to highlight areas at risk to insect-related damages using VMap and the R1 Forest Insect Hazard Rating System criteria (Randall et al, 2011). The hazard ratings assist managers in determining the potential for these disturbance agents on the landscape and help prioritize areas for hazard reduction management actions. For the 3 primary insects, mountain pine beetle, Douglas-fir beetle, and western spruce budworm, a modeled hazard map and an aerial detection survey map of know activity over the past decade is provided. See the Mud Creek Silviculture Priorities and Process document for further details (PF-SILV-004). Additionally, an entomologist and pathologist visited the project area in 2020. See the Insect and Disease Considerations in the Mud Creek Project Area report for further information (PF-SILV-009).

Mountain pine beetle (MPB) has impacted a large percentage of the project area over the past decade (Map 3). MPB was active at an epidemic or sudden widespread increased levels peaking between 2010 and 2013, however, it is still present at lower, baseline and naturally occurring endemic levels. Currently, 8,227 acres of ponderosa pine, lodgepole pine, and whitebark pine (all MPB host species) contain moderate to high hazard ratings (Map 4). While MPB is native to the area and will likely always exist at lower endemic levels in the area, it is desirable to prevent another epidemic. Gillette et al (2014) states, “Direct control methods have often been ineffective at large scales… however indirect control through proactive silvicultural treatments has the capacity to create forests that are more resilient in the face of multiple threats, including those that are exacerbated by climate change.” A reduction in stand densities will increase airflow and bole heating, and reduce water and nutrient stressors, allowing the trees to naturally better defend themselves and increase stand resilience to future beetle attacks.

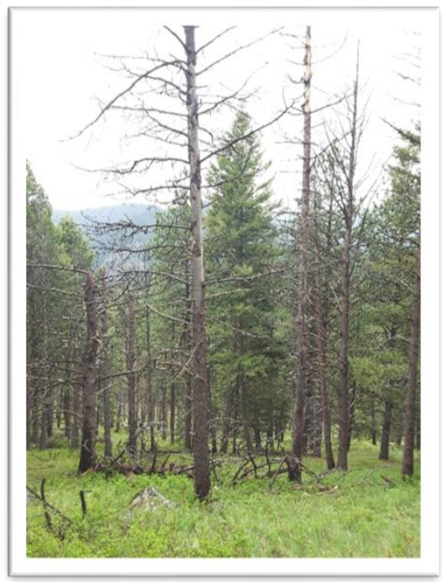
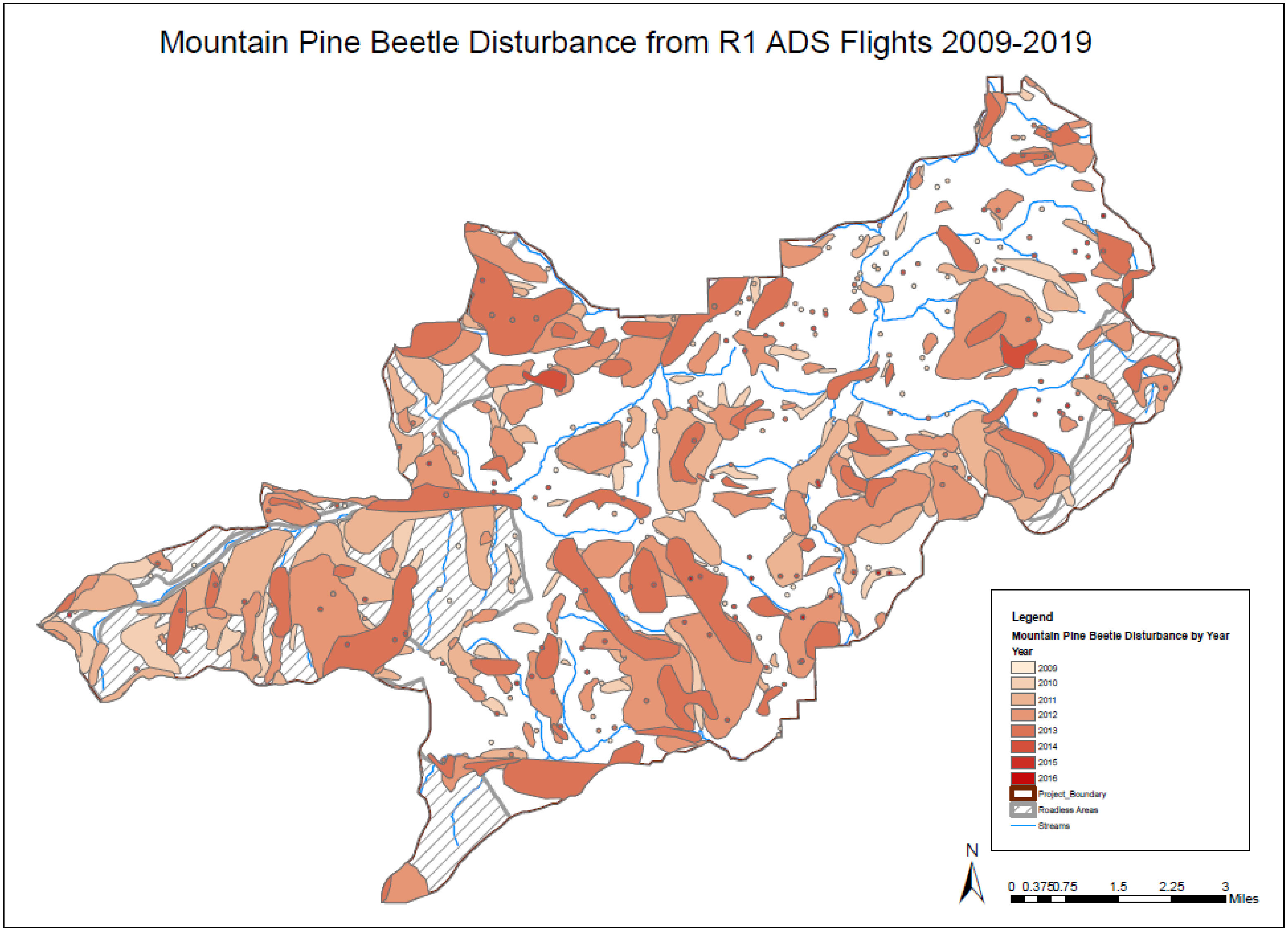
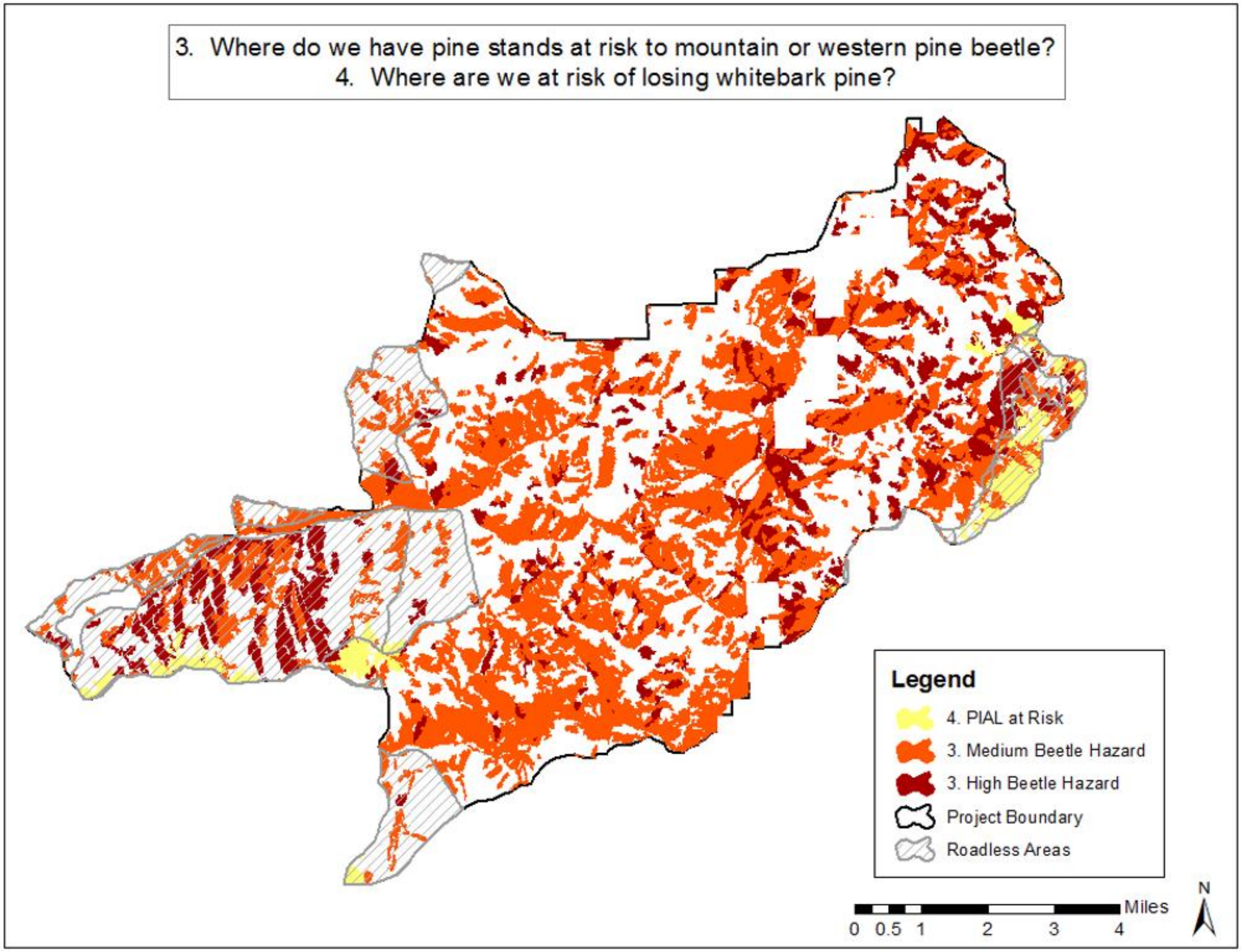


Figure 13: Mountain pine beetle killed ponderosa pine

Map 3: Aerial Detection Survey Map of Mountain Pine Beetle Activity



Map 4: Mountain Pine Hazard Rating Map



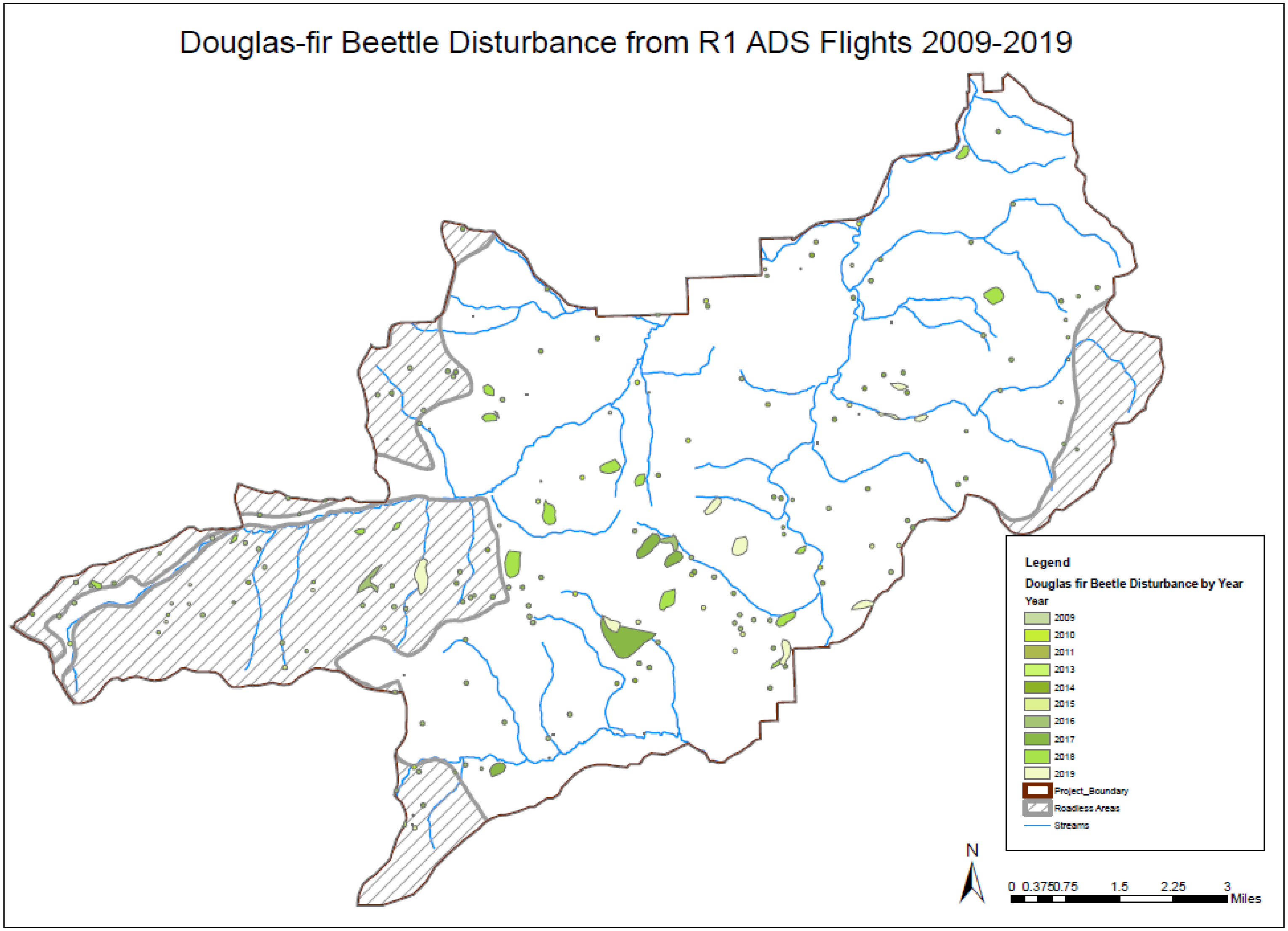
Douglas-fir beetle (DFB) activity has been increasing over the past 2 - 3 years in the project area (Map 5). Figure 14 is an image of Douglas-fir crowns fading to yellow, then red due to Douglas-fir beetle attacks. Figure 15 shows the frass or boring dust as a result of beetle attacks. Currently, 14,664 acres have a moderate to high hazard rating (Map 6). DFB is attracted to stands with a higher percentage of Douglas-fir, which are older ($\geq$ 120 years old), larger in diameter ($\geq$14” DBH), and have high stand densities ($\geq$ 250 ft^2/acre of BA) (Randall et al, 2011). Douglas-fir beetle is also attracted to stands that are additionally weakened by western spruce budworm defoliation, root disease, or dwarf mistletoe infections. Blowdown from a wind event or bole and crown scorch from a fire additionally attract DFB and cause an increase in the beetle population to the level of an outbreak that can be impactful to the larger landscape (Egan et al, 2018).

Note: During the field season of 2020, a sample of the project area was visited and personnel found more current Douglas-fir beetle activity present in green trees than is mapped in the latest aerial detection survey maps.

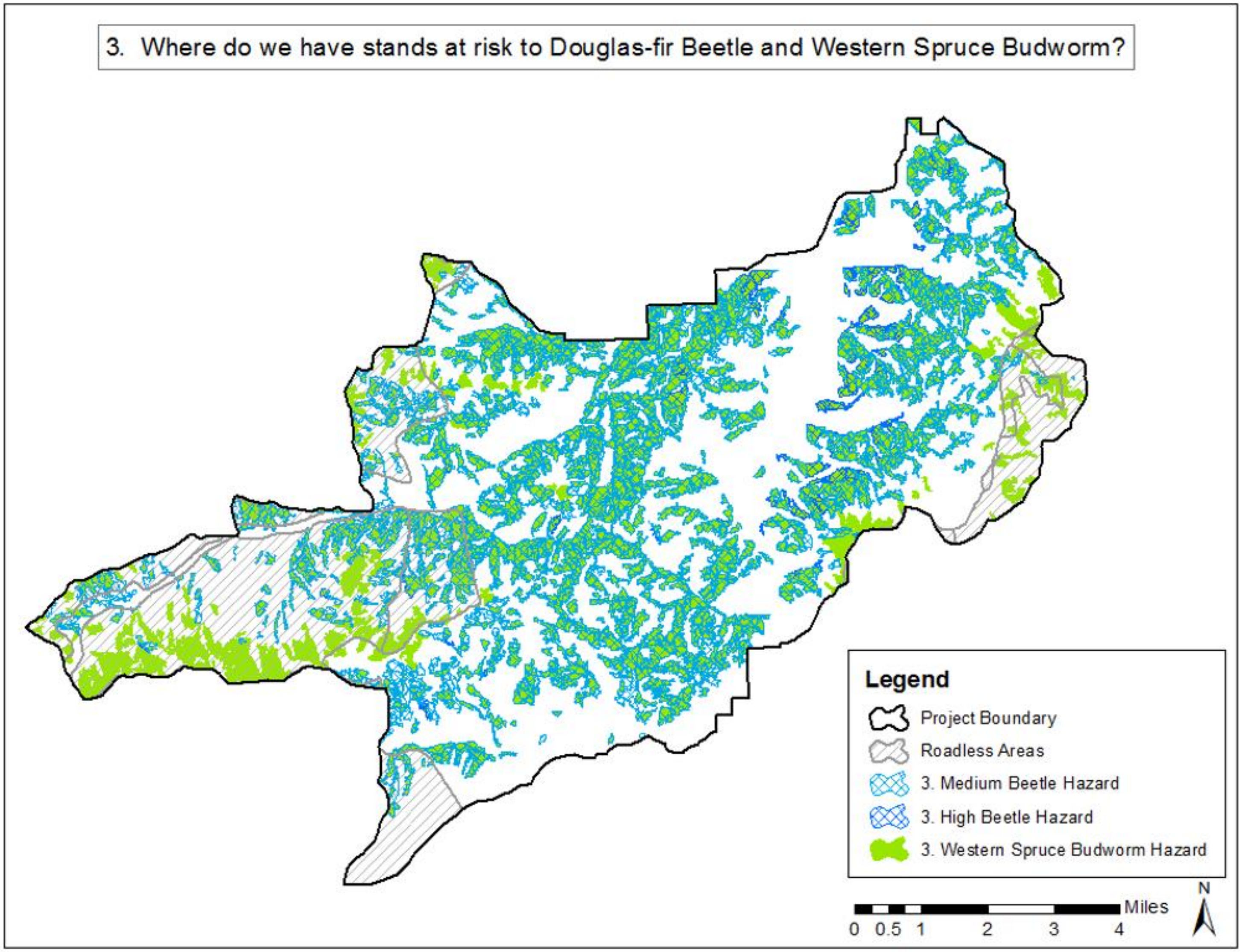
Figure 14: Douglas-fir beetle pocket of mortality

Figure 15: Frass (boring dust) from Douglas-fir beetle

Map 5: Aerial Detection Survey Map of Douglas-fir Beetle Activity



Map 6: Douglas-fir Beetle and Western Spruce Budworm Hazard Rating Map



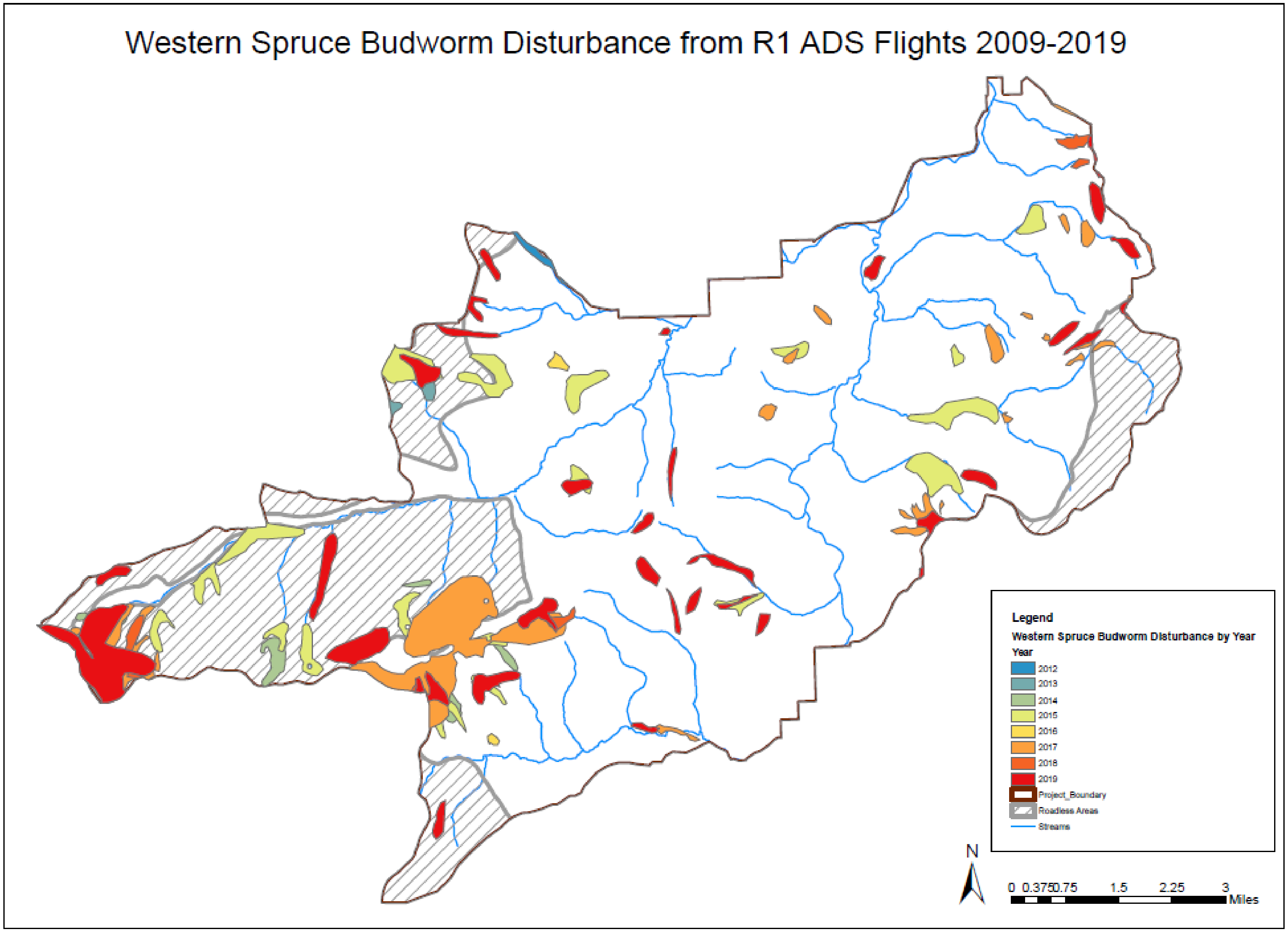
Western Spruce Budworm (WSB) is present in Douglas-fir, subalpine fir, and grand fir with defoliation ranging from light to heavy throughout the project area. Map 7 identifies areas of significant defoliation through aerial detection, however, 15,801 acres contain stand conditions with increased risk to defoliation (Map 6). Throughout the project area, the lower canopies in multistoried stands are experiencing the heaviest defoliation and in some cases, complete defoliation and mortality (Figure 16 and 17). The overstory often ranges from light to moderate defoliation. Mortality is associated with suppressed or younger trees in multistoried stands though mature trees may also die depending on the length and intensity of the outbreak and general tree vigor (Montana DNRC). Epidemic proportions can also reduce growth and cause top kill in mature host trees (Randall et al, 2011).

Note: During the field season of 2020, a sample of the project area was visited and personnel found more western spruce budworm activity and mortality in the understory than is captured in the latest aerial detection survey maps.

Figure 16: Western spruce budworm defoliation

Figure 17: Understory mortality related to budworm defoliation

Map 7: Aerial Detection Survey Map of Western Spruce Budworm Activity



Parasitic Plant

"Across the project area, infections in both lodgepole and Douglas-fir ranged from light (dwarf mistletoe rating [DMR] < 3) to severe (DMR > 4). Dwarf mistletoes (*Arceuthobium* spp.) are parasitic angiosperms that reduce diameter and height growth, alter tree form, reduce seed production, and can cause mortality. Stress and loss of vigor caused by systemic DM infections can also increase susceptibility to insect attack. DM are parasitic plants that utilize both water and nutrients from the tree host and stimulate production of large witches' brooms (proliferation of branches). DM is mostly spread by explosively discharged seeds that are propelled by a buildup of water pressure. Although seeds can travel up to 52 ft. (Worrall, 2014), the average horizontal distance of seed dispersal is 20 ft. and 90% of seeds land within 30 ft. of the infected canopy. The maximum seed dispersal distance may be farther on steep slopes or where high winds occur. Long distance spread is less common, occurring when the sticky seeds attach to birds or mammals and are later deposited on a susceptible host. DM spreads less than 2 feet per year on average in a single-story stand but can spread much more quickly in multistory stands where dwarf mistletoe seeds fall from overstory infections onto understory trees." (Steed & Bennett, 2021). Further, dwarf mistletoe leads to "brooming", these brooms can be quite flammable and spread fire into the crowns of trees (Hoffman, 2010).

Levels of infection are based on the Hawksworth system, which is a scale from 0 to 6, with 0 having no infection and 6 being fully infected. Tree canopies are broken into three equal length discrete sections vertically and each section is assigned an infection rating from 0 to 2. Each of the three ratings is then added together to reach a final rating of 0 to 6. Ratings of 3 or higher generally mean that the tree must be removed to slow the spread of infections among other susceptible trees in the stand (Hawksworth, 1977). Trees with ratings less than 3 may be kept depending on the long term stand objectives. The Mud Creek project area has the full range of mistletoe infections from minimal or no infection (Hawksworth rating 0-2) to numerous stands with heavy infections (Hawksworth rating 6; Figure 18) that are leading to top kill, tree mortality and are attracting Douglas-fir beetle.

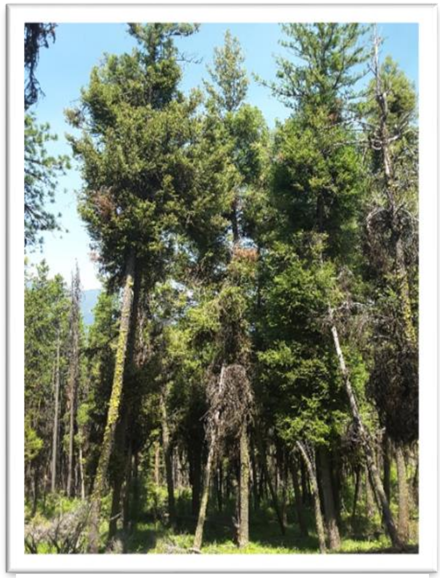


Figure 18: Douglas-fir with a dwarf mistletoe Hawksworth rating of 6.

Disease

White pine blister rust is a non-native fungal disease that infects five-needle pines (whitebark pine in the Mud Creek project area) that was introduced to the western United States in 1910. White pine blister rust requires living host tissue, and it requires two hosts, five-needled pines, and shrub or herbaceous alternate hosts, to complete its complex life cycle. Infections occur through needles by spores that come from alternate hosts in late fall during periods of high humidity. The rust fungus grows through branches toward the bole about 2 inches per year, killing tissue as it advances. Once the fungus reaches the bole, it creates stem cankers that eventually girdle the stem and kills or top-kills the tree. All sizes of trees are attacked, and small regeneration can be killed rapidly. (Schwandt et al. 2013)

Figure 19: White pine blister rust aeciospores

Annosus root disease, common on the Bitterroot National Forest, primarily affects ponderosa pine however, it can affect Douglas-fir, grand fir, and subalpine fir. Annosus and other root diseases cause decay in the roots of the infected trees, preventing the uptake of water and nutrients, which increases the susceptibility to bark beetle attack and eventually leads to mortality. The spores infect freshly cut stump surfaces and basal wounds. Once infected, the fungus will grow through the root system and can infect neighboring pine through root-to-root contact. Annosus root disease is a 'disease of the site' and will remain as long as host trees are present within the stand (Lockman 2011). Schweinitzii root disease is present in the project area impacting Douglas-fir causing root and heart rot decay in the bole of the tree. Conks can sometimes be found indicating root disease presence in a stand (Figure 20).

Figure 20: Schweinitzi root rot conk

Other insects, root diseases, Comandra blister rust, and elytroderma needle cast are present in the project area at lower infection rates or populations. A stand diagnosis will be completed for each treatment unit and inform management actions during the implementation phase. (See Implementation Plan, Appendix B)

Departure from Early-Settlement/Natural Conditions

Knowledge of historical ecosystem structure and processes and the range in which they varied offer a better understanding of how disturbance, vegetation, and other ecosystem components interact and in turn how their interaction affects biophysical elements such as plants, animals, fish, and soil and water resources. Historical perspectives increase our understanding of the dynamic nature of landscapes and provide a frame of reference for assessing current and future patterns and processes. The knowledge gained from the past can be used to help inform how climate change may affect future landscape conditions. (Bollenbacher et al, 2014) Veblen (2003) notes that historical perspectives can reduce the chances of major future surprises.

Losensky (1993) used fire history investigations, bog analysis, and early timber inventories to determine the "natural" vegetation that was present at the time Euromericans more notably settled the area with the development of the railroad in the early 1900s. For comparison, Table 3 provides the historical percentage of acres by cover type and age class for the Bitterroot climatic region. VMap existing size classes were used to compare the historic data to the currently available data (Table 3). Additionally, field measured FIA data was used to compare existing conditions to historic conditions in Table 4.

Table 3: Losensky's Historical Vegetation Compared to Current Vegetation

Cover Type (Losensky)	Nonstocked		Seedling/ Sapling (0.1 -4.9" DBH)		Poles (5.0 – 9.9" DBH)		Mature (10.0 – 19.9" DBH)		Over-Mature (>20.0" DBH)	
	Hist. (%)	Vmap (%)	Hist. (%)	Vmap (%)	Hist. (%)	Vmap (%)	Hist. (%)	Vmap (%)	Hist. (%)	Vmap (%)
Ponderosa Pine	8	N/A	9	5	8	34	19	61*	56	.3*
Douglas-fir	14	N/A	17	.1	16	11	20	89*	33	.1*
Lodgepole pine	11	N/A	37	8	41	43	8	48*	3	1*

*Vmap under-represents the largest size-classes by using QMD as a metric. Therefore, it is important to look at both the mature (10.0 – 19.9" DBH and the >25" DBH categories jointly to get a better understanding of the overall larger size classes present on the landscape.

Table 4: Losensky's Percent Area by Cover Type for Ravalli Co. compared to FIA Data for the West Fork District

	PP	L-DF	DF	ES	LP	SALP	NCF	NF
Ravalli Co.	17.9 %	0.7 %	9.0 %	0.3 %	6.5 %	25.5 %	21.0 %	19.1 %
FIA (West Fork)	8.3 %	N/A	28.8 %	5.3 %	25.2 %	13.2 %	N/A	12.6 %

The departure from historic conditions in Table 3 and Table 4 is also supported by Hessburg's study on recent historical conditions and current vegetation composition and structure using randomly sample watersheds in the Columbia River Basin (Hessburg et al, 1999). In addition to the shift in species composition, stand density, stand structure, and the diversity of structural stage, age class, patch size, and connectivity have all shifted

Species Composition

Ponderosa pine once dominated the warm and dry forest types (Lozensky, 1993; Hessburg et al, 1999; Arno, 1976). VMap based existing conditions show Douglas-fir is the most prevalent dominance type now. Losensky's data for Ravalli County when compared to FIA current field verified grid data show a 9.6% decrease in ponderosa pine and a 19.8% increase in Douglas-fir on the landscape. Hessburg's (1999) results show ponderosa pine present as the most significant decrease at 23% decline while subalpine fir and spruce cover types showed the most significant increase and whitebark pine and subalpine larch declined by 19%. VMap Rapid Assessment queries identified 5,045 acres within the project area where ponderosa pine is at risk of being out-competed by shade tolerant species.

Stand Density

In the absence of fire, stand density has increased from historical conditions (Hessburg et al, 1999; Hessburg et al, 2005). VMap Rapid Assessment queries identified 6807 acres where ponderosa pine or lodgepole pine are at risk to density related mortality.

Stand Structure

When comparing Losensky's historic reference data to VMap's current size class data, there is a clear shift in size class and successional stages by cover type.

Ponderosa pine seedling/sapling size class (0.0-4.9" DBH) has decreased, pole size class (5.0-9.9" DBH) has increased likely due to past management actions and terraced plantations, and the mature and over-mature size classes (≥ 10.0" DBH) had decreased. The greatest decrease is in the over-mature size class (20.0" DBH) however due VMap's use of QMD to identify size classes, it is known that VMap under-represents the largest size-classes when large trees are averaged with smaller trees in multi-storied or multi-size class stands. Nonetheless, based on knowledge of the project area and field review, the larger sized ponderosa pine are experiencing age-related mortality.

Douglas-fir seedling sapling size class (0-4.9" DBH) and pole size class (5.0-9.9" DBH) has decreased while the mature and over-mature size classes (≥ 10.0" DBH) has drastically increased. FIA data shows Douglas-fir make up the greatest percentage of over-mature (> 20.0" DBH) trees in the West Fork District.

Lodgepole pine seedling sapling size class (0-4.9" DBH) has drastically decreased while the mature and over-mature size classes (≥ 10.0" DBH) have hugely increased.

Size Class Diversity at the Landscape Scale

The results above show a landscape that is becoming dominated by shade tolerant, mid to late successional species. The stands are becoming more heavily stocked with dense layers of shade tolerant species. At the landscape scale, the forest has shifted to a more homogenous late successional stage dominated by mature and over-mature size classes (≥ 10.0" DBH). There is a significant decrease in the number of younger structural stages and smaller size classes. Hessburg's (1999) results found the most significant loss was in the stand initiation stage to seedling sapling size class (0-4.9" DBH), a 30% decline. Patch size in these young stands declined and was attributed to fire suppression and small historic clearcuts. Open canopy stem exclusion (common in pole-sized ponderosa pine) stands had a decline in connectivity and mean patch size declined. Stem exclusion closed canopy (common in pole size lodgepole pine) stands had a 26% increase in area, an increase in connectivity, and the mean patch size increase by 255%. Understory reinitiation (transitional period to becoming a multi-storied stand) declined in area and connectivity and the mean average patch size declined by 30%. Old multi-storied structures declined slightly, connectivity increased significantly, and mean patch size increased fourfold.

Connectivity in terms of landscape diversity describes how homogenous a landscape is. Connectivity in the Mud Creek project area has increased as forests age, fires are suppressed, and there becomes less diversity in species composition, stand densities, structural stages, and size classes. Past management in small blocks has also negatively decreased connectivity through creating too many patch sizes smaller than the average natural range of patch size variability found as a result of natural disturbances (Hardy et al, 2005).

Restoration Priorities for Landscape Resilience

Based on the existing condition and departure from early settlement natural conditions, the following forest conditions and dominance types are highlighted as restoration priorities to improve landscape resilience to disturbance.

- Mature ponderosa pine is a priority species of focus to improve landscape resistance and resilience to disturbance due to its natural characteristics that help it survive wildfire and drought plus its natural historic presence on the Mud Creek landscape. Ponderosa pine dominance is approximately 64% of its historic level (See Mud Creek Silviculture Priorities and Process document, PF-SILV-004). To improve resiliency, treatments that favor this fire dependent, early seral, shade intolerant species are necessary. Non-commercial and commercial treatments shall be designed to feature this species and provide the open growing conditions ponderosa pine thrives in. Uneven-aged group selection and individual tree selection treatments will be used to feature the scattered legacy pines and allow for clumps and openings with the goal of establishing a new age class. Improvement cuts will also be used to improve stand conditions to carry healthy ponderosa pine stands into the future. Non-commercial thinning will feature young cohorts and provide growing space to increase tree health, vigor, and resilience. Prescribed fire will be used to reduce fuels, manage the ingrowth of shade tolerant species, and provide the many benefits of a natural fire return interval as well as provide desirable conditions for natural seed germination.

- Mature Douglas-fir is approximately 244% of its historic level (See Mud Creek Silviculture Priorities and Process document, PF-SILV-004). This species is a prolific seeder and grows in the shade of overstory trees and on a wide range of aspects and elevations. This species is an important part of the landscape but without disturbance, it has increased to levels that do not provide landscape resistance or resilience. Treatments shall be chosen to feature healthy and desirable individuals where present with intermediate treatments such as improvement cut and sanitation cuts. Where conditions do not and will never meet the desired future conditions, regeneration treatments such as shelterwood cuts, seed tree cuts, or clearcuts with reserves will be used to reset the stand allowing for a new age class to establish. Non-commercial treatments including thinning and prescribed fire shall be spatially chosen to meet a range of desired conditions including fuels reduction, the reduction in the spread of insects and disease, and wildlife habitat.

- Mature lodgepole pine is approximately 288% of its historic level (See Mud Creek Silviculture Priorities and Process document, PF-SILV-004). Lodgepole pine is a fire dependent species with a relatively shorter life cycle and stand replaces upon maturity. Mountain pine beetle mortality is another type of stand replacing disturbance in this forest type. Lodgepole pine is found in the higher elevations of the project area and often overlaps with mapped lynx habitat. Where feasible, mature lodgepole pine stands should be considered for regeneration treatments to mimic the natural process of stand replacing fire and/or beetles, reset the successional cycle and increase age and size class diversity. Late seedling - sapling stages may offer the opportunity to increase hare habitat therefore increasing lynx foraging habitat.

- While it only makes up a very small percentage of the analysis area, treatments should be prioritized to improve and maintain whitebark pine on the landscape. These treatments will likely focus on whitebark pine daylighting, improvement cuts, prescribed fire, and planting blister rust resistant seedlings.

Environmental Consequences

No Action

Direct and Indirect Effects

Under the No Action Alternative, none of the proposed activities would occur. Continuing with the No Action alternative will cause current vegetation conditions to continue to move further away from desired conditions until a natural disturbance resets the system. The consequences of this are as follows.

Species Composition

There would be no proposed activities to change the species composition. The departure between existing and desired conditions (Table 3) would continue and will likely increase if no action is taken. Over time, mid and late seral species (Douglas-fir, grand fir, subalpine fir) will dominate the landscape. In the warm and dry forests, early seral species such as ponderosa pine will be outcompeted by shade tolerant species, mostly Douglas-fir. Historically, fire-dependent and fire-resilient ponderosa pine dominated the project area whereas currently, the stands have grown dense with shade tolerant species. Ponderosa pine will continue to have less regeneration success due to overcrowded stand conditions and less presence on the landscape in the future. In the cool and moist forests, subalpine fir will continue to establish in the understories creating even denser stands, easily spreading insects and disease, and will continue to increase the risk of large stand replacing fires. In cold forests, whitebark pine will be outcompeted by lodgepole pine and subalpine fir. Over time, this threatened keystone species will fade out of the project area and the larger ecosystem.

Stand Density

Stand densities will remain at high stocking levels and continue to increase with the ingrowth of shade tolerant species. This will continue to have a ripple effect causing an increased risk for insects, disease, and wildfire.

Structural Stages

Stand structure and size class distribution across the landscape will remain at current levels or fall further from desired conditions. As such, the Mud Creek area would be less resilient to disturbances and less diverse for wildlife. At the landscape scale, the area would become more homogenous and less diverse in species compositions, structural stages, and size classes. Over time, in the absence of fire, the project area would continue to shift towards mature stands containing more insect and disease-prone species, such as Douglas-fir, subalpine fir, and grand fir. Very little early successional, seedling/sapling stands would be present on the landscape, the majority would fall into the mature size classes that are currently and will continue to experience more insects and disease and store less carbon. Very few stands will have growing conditions to reach the larger size classes to become future old growth. The departure from Lozesky's historic conditions in Table 3 would continue and likely grow further apart.

Insects and Disease

Insects and diseases will continue to attack trees in the Mud Creek project area and forest health will continue to trend downward. Greater stand densities, greater percent species composition of desired host species, and a greater number of canopy layers in aging stands will continue to provide ideal conditions for insects and disease to spread with ease. See PF-SILV-009 Forest Health Protection Trip Report for more details.

Fire and Fuels

Heavy fuel loading from increased tree mortality and ladder fuels from increased ingrowth of shade tolerant species in the understories will continue to be abundant in the project area. Standing dead trees from insect-related mortality will continue to fall over, converting the fuel loading to a more lethal horizontal arrangement. The continuity of dense, older stands and/or stands with high mortality will allow fire to spread easily at high intensity over larger areas.

Old Growth

There will be less potential for stands to reach old growth status or maintain old growth status due to stands succumbing to fire, insects and disease. The majority of the old growth in the project area is a result of historically frequent fire keeping competition from shade tolerant species low. The current trajectory will see a continued decline in overgrowth development. There is no need for a site-specific Forest Plan amendment in the No Action alternative.

Climate and Carbon

In the No Action Alternative, the Mud Creek project area will not make shifts towards a more resilient landscape. As the temperatures continue to warm, the shift in species composition, increased stand densities, and homogenous size class distribution will put the project area on track for more frequent and extensive wildfires and insect outbreaks. The project area will likely not have the ability to return to its prior condition following higher severity disturbances.

Carbon storage will continue to decline as aging stands decrease in productivity and experience greater mortality. If the area was to continue on the current path, given all the items listed above, a potential large wildfire would cause significant carbon emissions. This is magnified by the shift in species composition away from fire tolerant species, the increased stand density that leads to stressed and aging trees that are at greater risk to insect and disease-related mortality and eventually, wildfire, potentially burning at higher intensities for longer periods of time over greater areas.

Cumulative Effects

Cumulative effects result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time. Under the No Action alternative, there would be no proposed activities to affect forest vegetation. Stands in the majority of the project area would continue to be dominated by current trends as described in the No Action direct and indirect effects section and displayed in Figure 21.

Future stand improvement thinning and slashing would improve growing conditions for early seral species plus reduce ladders and reduce the risk of insects and disease in the sapling to pole sized stands.

However, the acreage of stands planned for thinning and fuels reduction is so small that the cumulative effect would be minimal at the project scale.

Future prescribed fire in the 15,755 acre Upper Nez Perce ecoburn will return fire to the landscape, reducing ladders fuels, thinning, or opening the overstory in areas of greater fire intensity. The Upper Nez Ecoburn will overlap with the Mud Creek project area by 2,938 acres in the upper Little West Fork drainage.

The 5,800 acres Piquett Creek Fuels CE boarders the Mud Creek project to the northeast. Commercial (approximately 500 acres), non-commercial, and prescribed fire treatments (3,000 acres maximum) will greatly benefit the forest vegetation in the Piquett Creek watersheds. These activities may change the potential for fire and insects to spread to neighboring stands in the Mud Creek project but do not affect the forest vegetation in the Mud Creek project area.

Summary

In summary, the forest vegetation would remain unchanged by proposed activities at present and will continue to move further from the desired conditions over time. Figure 21 highlights the decline in desired species composition, stand density, structural stages, and landscape heterogeneity that makeup and define landscape resiliency.

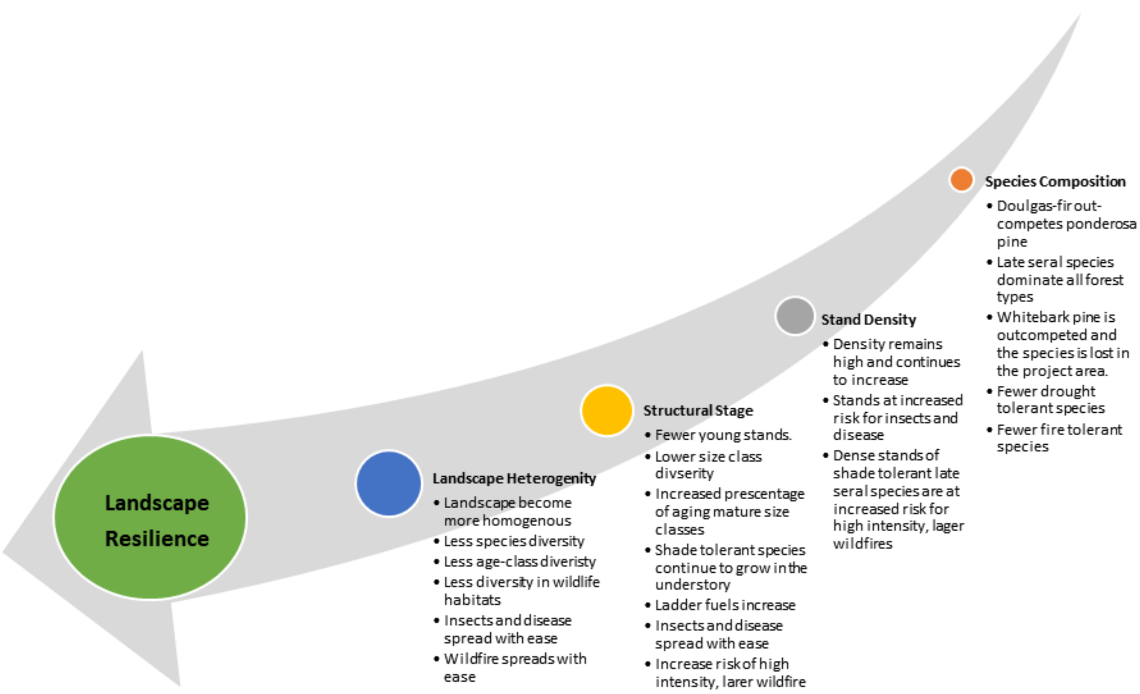


Figure 21: A decline in forest resiliency at the landscape scale

Proposed Action

The proposed action is designed to improve landscape resilience to disturbances such as insects, disease, fire, and drought through a combination of intermediate treatments, regeneration treatments, stand improvement non-commercial treatments, and fuels reduction treatments including prescribed burning. With a century of fire suppression and decades of past management actions, in many cases, it is not possible to reach the desired future condition in one entry. The objective of the treatments is to move the needle on the scale of landscape resilience to disturbance. Table 5 summarizes the maximum potential acres that could be treated. These acreages do not represent a cumulative total of acres treated within the project area. Multiple treatments may take place on the same acre of land depending on the existing conditions and steps needed to move toward the desired future condition. The proposed activities within the project area will take place over a 10-20 year timeframe. Appendix A contains design features for all proposed treatments describing each treatment, the objectives, where it would most likely occur, Forest Plan or applicable laws, and design features. The Treatment Diagnosis Crosswalk (PF-SILV-005), provides a general description of the forest types found in the Mud Creek project area, the desired future condition, and some of the tools that may be used to move the stand towards the desired condition.

Table 5: Summary of proposed vegetation management activities

Proposed Forest Vegetation Management Activities *(See Appendix A for vegetation management design features and treatment descriptions)*	**Maximum Potential Treated Acres**
Regeneration Treatments: includes Seed Tree Cut and Shelterwood Cuts (VM-02), Clearcuts with Reserves (VM-01), and Group/Individual Selection (VM-04)	4,800
Intermediate Treatments: includes Improvement Cuts and Commercial Thins (VM-05)	8,900
Non-commercial Intermediate Treatments: includes Stand Improvement Thinning and Slashing (VM-06), and Whitebark Pine Daylighting (VM-10)	26,478
Prescribed Fire for Site Preparation (FM-03)	4,800
Low- Severity Prescribed Fire (FM-01) and Maintenance Burning (FM-04)	28,235
Mixed- Severity Prescribed Fire (FM-02)	12,125
Other Treatments: includes Tree Planting (VM-08), Meadow Restoration (VM-13), Aspen Restoration (VM-09), Native Plant Revegetation (VM-14), Biological Weed Control (VM-11), Mastication (FM-09), Chipping (FM-10)	No Maximum Set

Direct and Indirect Effects of Silvicultural Treatments

Regeneration Treatments – Even-Aged and Two-Aged

The direct effects of regeneration harvest treatments would be the removal of the majority of the overstory trees. Residual trees left on site would be selected for seed production, shelter, and/or snag retention objectives. Even-aged or two-aged regeneration treatments include Shelterwood Cuts, Seed Tree Cuts, and Clearcuts with Reserves.

Indirectly, resilience to fire, insects, disease, and drought will increase at the stand and landscape-scale as stand densities are lowered, and desired species composition, structure, and age class diversity are achieved. A new age class would be established featuring site-specific early seral species and the seedling/sapling successional stage (size class) will improve landscape heterogeneity. Planting of site adapted seedlings will increase genetic diversity.

Openings Greater than 40 Acres

Historically, fire created openings ranging in size from small to much larger than 40 acres within the landscape that the Mud Creek project resides. The term "openings", as used here, includes areas with a range of residual tree densities. In the cool and moist forest types, fire often burned with greater intensity creating stand replacing openings that appeared as a mosaic of burned and unburned areas across the landscape. Meanwhile, in the warm and dry forest types, more frequent low intensity fires created open stands with a variable number of surviving trees. In some cases, the majority of the stand survived, in other cases, only the most fire tolerant species and individuals survived, leaving behind an open grown stand with individuals left to provide seed for a new age-class.

Additionally, insects, such as the mountain pine beetle, have created larger openings, primarily in lodgepole pine stands in the project area during the last mountain pine beetle epidemic. As the dead standing trees begin to fall and fuel accumulations increase, these stands may be more likely to burn with greater intensity, creating larger openings. Managing forests for their natural fire regimes by creating new openings consistent with natural disturbance processes are important for improving age class diversity (Churchill et al, 2013; Arno & Fiedler, 2005).

The maximum size opening in the Northern Region created by clearcuts, seed tree cuts, or shelterwood cuts designed to regenerate an even-aged or two-aged stand of timber in one harvest operation shall be 40 acres as a standard in the Bitterroot Forest Plan. Creation of openings larger than 40 acres requires 60-day public review and Regional Forester approval. Additional information and regulations can be located in NFMA (16 USC 1604 (g)(3)(F)(iv)) and planning regulation (36 CFR 219.11(d)(4 (i)-(ii)). Additional information can be found in the Regulatory Framework section of this document.

In the present day, the need to create openings greater than 40 acres in size, through the use of even-aged or two-aged silvicultural treatments, is anticipated in the Mud Creek project. During the 2020 field season, an entomologist and pathologist from the USFS Northern Region, Forest Health Protection Missoula Field Office visited the project area to look at various insects, diseases, and forest health conditions. Of the damage agents found, dwarf mistletoe was the most wide-spread management issue.

> *"Dwarf mistletoe is a major management concern for Douglas-fir and lodgepole pine stands, with varying levels of incidence and severity across the project area. Intermediate or regeneration treatments that create multi-storied stand conditions with infected overstory trees will perpetuate the disease cycle."* (Steed & Bennett, 2021)

Figure 22: Douglas-fir Trees with Severe Dwarf Mistletoe Infections in Upper Two Creek (Steed & Bennett, 2021)

Other damage agents found and noted in the trip report include mountain pine beetle in all pine species (ponderosa, lodgepole, and whitebark) and Douglas-fir beetle, white pine blister rust caused mortality in whitebark pine trees, pine engraver, western spruce budworm defoliation throughout the project area, elytroderma needle disease, and native root diseases including armillaria, annosus, and schweinitzii are also wildly scattered in the project area and surrounding areas. While many of these damage agents are currently present at endemic levels, we are seeing an increase and greater presence of Douglas-fir beetle and western spruce budworm in the field than is reported in current aerial detection surveys. The continuity of moderate to high hazard stand conditions for all insects will also benefit from treatment in various patch sizes.

Stands infected with dwarf mistletoe are present throughout the project area in warm and dry and cool moist forest types. Because both Douglas-fir and lodgepole pine are impacted, dwarf mistletoe is present on the landscape in contiguous areas greater than 40 acres in size. The locations of the greatest concern are the habitat types that feature Douglas-fir and lodgepole pine as early seral species. To manage for desired future conditions, it is critical to remove or minimize the infection within the stand and to the same scale dwarf mistletoe is present, to the extent possible. Acknowledging mistletoe's explosive method of spread, the fact that most seeds land within 30 feet of the infected canopy, but knowing the maximum seed dispersal distance may be much further on steep slopes, found in Mud Creek, where high winds occur, it is clear to see how an infected neighboring stand can easily infect a new age class in less than 40 acre treatment units (Dooling, 1974, Worrall, 2014). Where cool and moist forest types are present and the natural and desired future species composition is Douglas-fir and/or a lodgepole pine mixed conifer stand, managing for species that are dwarf mistletoe host species, requires treatments at a larger scale, representative of the level of infection in the area. Two-aged treatments need to be free of overstory dwarf mistletoe infections to promote and grow a healthy future second age-class. In the warm and dry forest types, where Douglas-fir is part of the desired future species composition, the removal of dwarf mistletoe is important to maintain a healthy Douglas-fir component in the overstory and the understory, and minimize flammable witches' brooms within the wildland urban interface. Where host species are desired as part of the future species composition, it is necessary to break the infection cycle to promote future stands with greater resilience to disturbances.

To manage for resilience within these currently infected stands, openings may be created, up to 200 acres in size. Opening sizes and locations will be determined based on site-specific conditions, infection severity, plus the natural disturbance processes, fire regime, patch size, and patterns typical of natural disturbances in these forest types, while remaining in compliance with Forest Plan management area goals. Openings will be created through the use of Seed Tree Cuts, Shelterwood Cuts, or Clearcut with Reserves even-aged (one and two-aged) silvicultural methods. The silvicultural method that best meets the current site conditions will be selected. Clearcut with Reserves may be the best treatment in some stands, however, the majority of the treatments will be Seed Tree or Shelterwood Cuts based on current

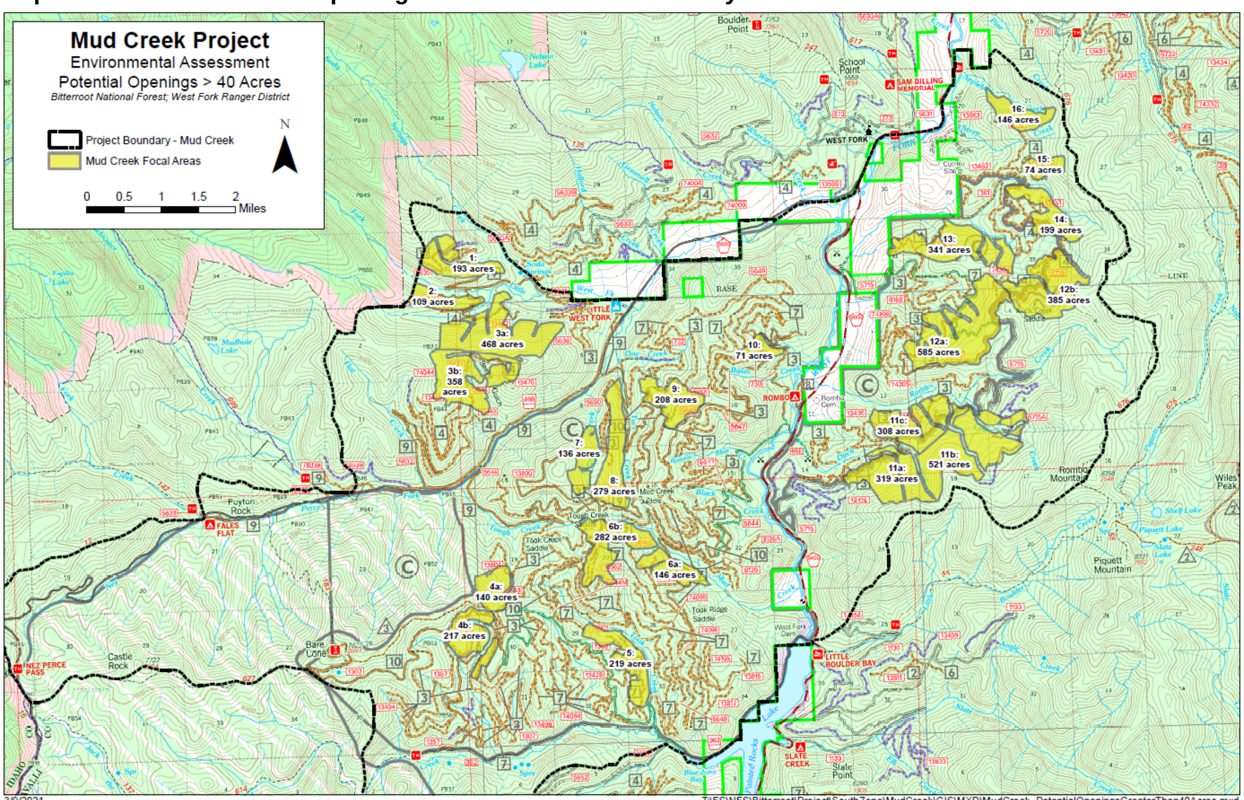
Figure 23: Example Post-Harvest Shelterwood Cut

conditions in the project area. Varying densities of trees will be retained within these areas, from scattered individuals to groups consisting of the largest, healthiest trees. See Figure 23 for an example of a local Shelterwood Cut photographed a few months following harvest. Compared to intermediate harvest areas or untreated forests, regenerated areas will appear as openings, with 0 to 20 square feet of basal area, until new trees grow to occupy the site.

Within the Mud Creek project area, Focal Areas have been identified where we anticipate the need for even-aged regeneration harvest openings, greater than 40 acres in size, to occur (See Map 8). These areas were selected based on satellite collected (VMap) dominant species composition, aerial flight surveys detecting insects and disease presence, past field-collected stand data (FSVeg), and current on the ground conditions based on recent field visits. During the implementation phase, openings ranging in size, but not exceeding 200 acres in size, may be planned within these focal areas. The optimal openings size and final treatment type will be determined upon stand diagnosis and field review by a certified silviculturist, to select the best treatment for current site-specific conditions. The maximum potential size is 200 acres, however, upon field review treatment units are anticipated to be less once the interdisciplinary team identifies additional resource needs such as wildlife habitat, old growth stands, sensitive soils, RHCAs, fisheries concerns, access and logging operability, and visual concerns.

See PF-SILV-008 Focal Areas- Potential Openings Greater Than 40 Acres In Size document for a larger map and table containing more details.

Map 8: Focal Areas Where Openings Greater Than 40 Acres May Occur



Treatments within the focal areas may vary from a regeneration harvests, intermediate harvests, and/or areas left untreated. Not all acres will be treated. No harvest is proposed within riparian habitat conservation areas (RHCA's) or old growth stands. Resource specialists will conduct field assessments, provided in the Implementation Plan (Appendix B), to select the areas best suited for treatment. More than one regeneration harvest unit, greater than 40 acres, may occur however the total of all even-aged regeneration harvests will not exceed 200 acres within any one focal area.

Hypothetical Example: Focal Area 3a – 193 total acres of two-aged regeneration harvests

- Unit 1: Shelterwood Cut – 86 acres
- Unit 2: Shelterwood Cut – 65 acres
- Unit 3: Shelterwood Cut – 42 acres

In this example, the three regeneration harvest units shall be spatially divided, but the total of all three cannot exceed 200 acres in size. Multiple focal areas are split based on forest types and anticipated treatment needs. Where focal areas are split (example: 3a, 3b), no two regeneration harvests will be located adjacent to each other and exceeding 200 acres in size. Adjacency will be determined based on wildlife, water, soils, and visual resource concerns with units situated and designed to minimize impacts to visual quality and blend with natural features to the extent feasible.

Examples of stand conditions that may lead to openings greater than 40 acres.

- Warm and dry Douglas-fir dominated mixed conifer stands (Douglas-fir and ponderosa pine- including historically ponderosa pine dominated stands) with Douglas-fir dwarf mistletoe, Douglas-fir beetle activity, mountain pine beetle activity, and/or western spruce budworm defoliation. Damage agents have impacted 50-90% of the stand and are causing tree mortality. Stand conditions currently contain moderate to high insect hazard rating based on stand age, diameter, and species composition. Desired conditions would be to promote healthy individuals for seed production, feature the early seral species, ponderosa pine, and a healthy component of Douglas-fir, and create microsite conditions for a new age-class to establish. Planting of early seral species may be desired. Early seral species composition, lower stand density, and age-class diversity will increase landscape heterogeneity and improve landscape resilience to insect, disease, fire, and drought (Halofsky et al, 2018).

- Cool and moist mixed conifer stands (Douglas-fir, lodgepole pine, Engelmann spruce, subalpine fir) with dwarf mistletoe present in both Douglas-fir and living lodgepole pine, high mortality (30-75%) and standing dead lodgepole pine from past mountain pine beetle activity, western spruce budworm defoliation, signs of schweinitzii root and butt rot, and/or western balsam bark beetle causing mortality in subalpine fir. The desired condition is a healthy new mixed conifer age class featuring Douglas-fir and/or lodgepole pine, depending on site conditions and habitat type. A regeneration harvest will reset the stand, site prep burning will provide microsite conditions for natural regeneration of lodgepole pine and potentially Douglas-fir. Age-class diversity will aid in a mosaic patch and pattern on the landscape, plus offer associated fuels reduction, increasing landscape resilience to insect, disease, and fire.

See the Regulatory Framework section for National Forest Management Act compliance and the Forest Service Manual requirements and PF-SILV-006.

Regeneration Treatments – Uneven-Aged

The direct effects of uneven-aged regeneration harvest treatments would be the removal of the majority of the overstory trees in small groups through Group Selection Cuts. This type of treatment will most commonly be used to restore ponderosa pine stands. Individual or single trees may be removed irregularly in other areas beyond the groups. Residual trees left on site would be selected for seed production, shelter, or snag retention objectives. This treatment will focus on retaining the large legacy ponderosa pine scattered throughout the project area, thinning the pockets with higher stand density, and creating openings to allow a new age-class to become established.

Indirectly, resilience to fire, insects, disease, and drought will increase at the stand and landscape-scale as stand densities are lowered, and desired species composition, structure, and age-class diversity are achieved. A new age class would be established featuring site-specific early seral species and the seedling/sapling successional stage (size class) will improve landscape heterogeneity. Where natural regeneration cannot be assured, seedlings grown from local trees and planted will increase genetic diversity. This treatment will aid in creating and/or retaining the natural clumpy distribution of mature ponderosa pine while creating openings to feature a new age class and restore ponderosa pine stands to a more natural uneven-aged structure, mimicking natural disturbances common to these forest types (Arno & Fielder, 2005). This treatment may be used to improve stand resilience in current old growth stands or promote future old growth stands.

Intermediate Treatments

Improvement Cuts and Commercial Thins

The objective of improvement cuts and commercial thins is to remove less desirable trees, improve species composition, reduce stand density, improve tree growth, and enhance forest health. In the warm and dry forest types, treatment would favor ponderosa pine over shade tolerant species. Based on site-specific objectives, the healthiest individuals (pointy full crowns, vibrant green needle coloration, well-formed, no signs of insects or disease) of all desired species would be retained. The direct effect would be a shift in species composition, reduction stand density, and an improved stand structure achieved by shifting the stand towards the number of desired canopy layers.

Indirectly, lowered stand densities will increase individual tree vigor, increase the tree's natural defense mechanisms to resist insects and disease and risk of spread, and reduce the risk of high intensity wildfire. At the landscape scale, lowered stand densities and productively growing forests store more carbon and increase forest resiliency to natural disturbance processes such as fire, insects, and disease.

Stand Improvement Thinning and Slashing

Similar to mechanical improvement cuts and commercial thins, stand improvement thinning and slashing remove less desirable trees, improve species composition, reduce stand density, improve tree growth and vigor, enhance forest health and reduce fuels in younger stands by hand crews. Increasing stand density is linked to increases in insect and pathogen-related mortality of stressed and host susceptible trees due to the increased competition for sunlight, water, and soil resources. In the warm and dry forest types, treatment would favor ponderosa pine over the less fire resistant, shade tolerant species such as Douglas-fir (Schowalter, 1994). Based on site-specific objectives, the healthiest individuals of all desired species would be retained. The direct effect would be a shift in species composition, reduction stand density, and an improved stand structure achieved by shifting the stand towards the number of desired canopy layers.

At the stand level, thinning increases the availability of resources to the residual trees indirectly lowering stand densities increases tree vigor, increases tree resilience to insect and disease, reduces the ability of insects and disease to spread, and reduces the risk of high intensity wildfire. At the landscape scale, thinning also increases resilience to a changing climate by reducing dense, overstocked stands and maintaining productive growing stands for carbon storage. Young healthy stands offer age class diversity and landscape heterogeneity, increasing landscape resilience to natural disturbance processes (Halofsky et al, 2018).

Prescribed Fire

Low severity prescribed fire and maintenance burning is primarily being considered in the warm and dry forest types as a treatment following harvest, as a treatment on its own to reduce fuels and restore fire as a natural process or to maintain desired conditions. The direct effect is a reduction in forest floor litter and duff as well as a reduction in understory shade tolerant small-diameter trees. Individual or small areas of trees of all size classes may die through primary or secondary fire effects, including root, bowl, or crown damage from direct flame, heat, or indirectly from beetles.

Indirect effects include stimulation and basal sprouting of forage species, improved habitat for fire adapted native plants, reduced canopy cover, reduced stand density, increased base canopy height, species composition shift to fire tolerant early seral species, and lowered risk of high intensity wildfire. Returning fire to the landscape, a natural fire dependent ecosystem, has numerous indirect benefits. Prescribed fire under controlled conditions will increase stand level and landscape resilience to wildfire.

Prescribed fire for site preparation prior to tree planting (moderate burn severity) and mixed severity prescribed fire have separate objectives but similar effects. The direct effects include the reduction of duff, forest litter, and shrub competition. The mixed severity levels reduce trees of all size classes that are not resistant to fire, especially shade intolerant species or younger trees with thinner bark. Trees may die through primary or secondary fire effects, including root, bowl, or crown damage from direct flame, heat, or indirectly from beetles.

Indirectly, the exposure of mineral soil enhances microsite conditions for trees to germinate and reduces competition for natural and planted regeneration to establish successfully. Other indirect effects include stimulation and basal sprouting of forage species, improved habitat for fire adapted native plants, reduced canopy cover, reduced stand density, increase base canopy height, species composition shift to fire tolerant, early seral species, and lowered risk of high intensity wildfire. Prescribed fire under controlled conditions will increase stand level and landscape resilience to wildfire.

With all prescribed fire treatments, there is an increase in carbon release during implementation however this is off-set by the increase in forb, shrub, and tree vigor in the long-term (Kurz et al, 2008; Birdsey et al, 2019) Prescribed fire and other management actions are often suggested as climate change adaptation actions because they may increase forest resilience to these multiple stressors thus increasing the likelihood of sustaining carbon benefits for the long-term (Millar et al, 2007; Joyce et al, 2008; Blate et al, 2009)

Tree Planting

Tree planting establishes and adds insurance in restocking a stand following harvest or disturbance. Planting often features early seral species, improved stock that is tested for desired genetic traits such as resistance to insects, and increases genetic diversity over-all. Indirectly, planting increases landscape heterogeneity and resilience through improved species composition and age and size class diversity.

Whitebark Pine Daylighting

Whitebark pine daylighting, a release treatment, directly removes other trees competing with the whitebark pine in a radius around each tree creating more growing space. Indirectly this treatment increases the tree's resources, improving tree vigor, health, and natural resilience to insects and disease. Daylighting removes competing and shade tolerant subalpine fir, may reduce the risk of mountain pine beetle attacks by removing lodgepole pine and lowering the stand density, and when combined with burning, removes fuels that may put the stand at risk to higher intensity wildfire (Keane et al, 2012; Sturdevant et al, 2015).

Other Treatments

Meadow Restoration, Aspen Restoration, Native Plant Restoration, and Biological Weed Control

These treatments all share a common objective to restore the native species. A combination of treatments above may be used to meet these objectives. Directly, treatments remove competition, encroaching trees or invasive species. Indirectly, this increases native plants, trees, wildlife forage and habitat diversity.

Direct effects of conifer removal for meadow restoration or aspen restoration is the reduction in competition and shade from encroaching conifers and the increase in moisture and nutrient availability. Indirectly, the removal of encroaching conifers may increase shade-intolerant native plant species and may increase aspen suckering (regeneration), improve aspen clone health, and improve wildlife habitat quality and diversity (Oregon State University, 2010). Burning may also desirably increase aspen suckering and presence as found on the Bitterroot National Forest following the 2000 fires (Benedict, 2010).

Mastication and Chipping

Both of these treatments shred trees and fuels into small pieces of wood or chips. The pieces are then scattered into the forest or hauled offsite. These treatments reduce fuels or rearrange how the fuels are configured, lowering the intensity and severity of the potential fire. Indirectly, caution needs to be used to not spread a thick layer of chips on the forest floor reducing native grasses, forbs, and shrubs. This will be addressed in the site-specific silvicultural prescription.

Road Construction

Temporary or specified road construction would occur where roads are necessary to facilitate project activities. Specified roads would stay on the landscape and become system roads. Temporary roads would be stored or decommissioned after the need for access is complete, at the end of the timber sale. The direct effects would be the removal of trees and vegetation, as well as soil disturbance through the road building efforts. The initial effects of temporary roads would be compacted soils in the roadbed which could limit or slow the natural regeneration of plants and trees. Obliteration would include reduced compaction, creating a more desirable seedbed for natural regeneration. Although temporary roads may impact tree regeneration through soil compaction, these effects are very minimal when considered across the scale of the project area and the access provided for acres of treatments designed to improve landscape resilience.

Direct and Indirect Effects on Resource Indicators and Measures

Effects of Treatment Activities on Species Composition

The proposed treatments under the proposed action will directly change the species composition of the affected sites by harvesting (removing) or non-commercially thinning or slashing predominantly Douglas-fir, lodgepole pine, subalpine fir, and grand fir. In the warm and dry forests, where early seral species are present, healthy ponderosa pine will be retained. In the cool and moist forests, healthy Douglas-fir, if available, will primarily be retained. In the cold forests, whitebark pine will be retained if present. Prescribed fire treatments will also favor the early seral species that are the most fire tolerant. Where planting occurs, site-specific early seral species will be chosen. The direct result in terms of species composition will be a shift from shade tolerant species to early seral shade intolerant species. Indirectly, early seral species are often the most fire tolerant and drought tolerant species for their desired site and offer long term benefits in the forest's resilience to disturbances including fire and a warming climate.

Effects of Treatment Activities on Stand Density

The proposed treatments will directly reduce stand densities. Regeneration treatments will have the biggest direct effect on stand density, however, intermediate treatments, and non-commercial thinning and slashing will greatly reduce the basal area and the number of trees per acre. Prescribed fire also reduces stand density to varying degrees in low-severity to mixed severity applications. Indirectly, trees in more open-grown forests with lower stand densities have more resources (water, sunlight, and nutrients) to grow vigorously and naturally resist insects and disease. More airflow disperses pheromones produced by beetles, and increases bole heating and cooling making for less inhabitable growing conditions for beetle larva. Other insects such as the western spruce budworm and the parasitic plant, dwarf mistletoe have less success spreading from crown to crown in more open-grown stands. Lower density stands also tend to burn at a lower severity if ladder fuels are not present. Crown spacing also prevents the ease of fire spread through the crowns.

Effects of Treatment Activities on Structural Stages

The proposed treatments will improve the desired structure within stands at the treatment unit scale and will increase size class diversity at the landscape scale. Treatment unit objectives vary based on site conditions. In the warm and dry forests, treatments including harvest, non-commercial treatments, and prescribed fire will all reduce the amount of shade tolerant species encroaching in the understory or those which have grown into the upper crown classes creating a multiple layered canopy that increases the spread of insects, disease and acts as a ladder fuel for fire. In the cool and moist forests, canopy layers may be reduced to prevent the spread of insects and disease. In some stands, multi-storied stands may be desired in specific areas for wildlife habitat. Each treatment will be site specific. Throughout all forest types, horizontally spread out age-classes are desired for early seral species dominance and to reduce the spread of insects and disease.

At the landscape scale, a variety of treatments that create conditions to support a variety of stand size classes will increase landscape heterogeneity. Specifically, regeneration harvests and mixed-severity fire create conditions for a new age-class of trees to establish (seedling/sapling size class) which is currently lacking on the landscape (Table 3). Intermediate treatments will improve stand-level conditions in the pole to early mature structural stages. Intermediate treatments such as improvement cuts or uneven-aged treatments such as group selection and individual tree selections can improve stand conditions to manage for mature to over-mature later structural stages. This combination of treatments will improve landscape heterogeneity by created a mosaic of size classes across the project area. Indirectly, diversity in stand structure and size classes changes the way fire, insects, and disease are able to move across greater areas.

Effects of Treatment Activities on Insects and Disease

Insect and disease concerns are addressed by shifting species composition towards the desired species, decreasing stand densities, reducing structure associated with the ingrowth of shade tolerant species, increasing structural stage diversity, and increasing size class diversity across the landscape. A landscape with greater diversity will be aligned to better respond to natural disturbances and restore natural processes (Halofsky et al, 2018). Likewise, shifting species compositions to early seral fire tolerant species, reducing stand densities, reducing ladder fuels associated with the ingrowth of shade tolerant spices, and increasing size class diversity across the landscape reduces fuels and the risk of larger and/or higher severity wildfires. See the Fire and Fuels report for more details (PF-FIRE-001).

Table 6: Insect and disease general management guidelines

	Mountain Pine Beetle and Western Pine Beetle (Randall et al, 2001; Gillette et al, 2014)	**Douglas-fir Beetle** (Kegley, 2011; Randall et al, 2011; Negron et al, 1999)	**Western Spruce Budworm** (Randall et al, 2001; Anderson et al, 1987))	**Dwarf Mistletoe** (Hoffman, 2010)	**White Pine Blister Rust** (Schwandt et al, 2013)	**Root Disease: Annosus Schweinitzii & Others** (Lockman, 2006; Rippy et al, 2005)
Host Species: Mud Creek	**Ponderosa Pine (Both) Lodgepole Pine (MPB) Whitepark Pine (MPB)**	**Douglas-fir**	**Douglas-fir Subalpine fir Grand fir**	**Douglas-fir & Lodgepole pine**	**Whitebark pine**	**Ponderosa pine (P-type annosum)** **Douglas-fir (Schweinitzii, Armillaria)**
Species Composition	Avoid managing for multiple pine species in one stand	Decrease percent of host species	Decrease percent host of species	Decrease percent host of species	Plant blister rust resistant seedlings, remove other competing species	Prevent Introduction or Manage for non-host species once root disease is established on site
Stand Density	Reduce stand density	Reduce stand density	Reduce stand density	Regenerate infected stands	Reduce stand density, remove competition	Reduce spread by radial clearing of host species around root disease centers
Structural Stage (Age)	Manage for age diversity	Manage for stands less than 120 years old	Manage for even-aged stands. Fewer canopy layers	Manage for even-aged stands. Fewer canopy layers	Manage for age diversity, reduce ladder fuels and risk of stand replacing fire	Manage for age diversity. Older trees are more susceptible to Schweinitzii
Size Class	Manage for size class diversity at the landscape scale	Manage for size class diversity at the landscape scale	Manage for size class diversity at the landscape scale	Manage for size class diversity at the landscape scale	Manage for cone-bearing trees and openings for Clark's nutcracker caching or planting	Manage for size class diversity at the landscape scale

Indirectly, treatment can have an undesirable effect on insect and disease activity. Basic management guidelines for the most common insects and disease can be found in Table 6 above. In order to address these concerns, project design elements are required to mitigate the risk of increased populations of pine engraver beetle (*Ips pini*) in post-treatment slash and minimize the potential spread of Annosus root disease. See applicable design features in Appendix A for each activity.

Effects of Treatment Activities on Fire and Fuels

Shifting species compositions to early seral fire tolerant species, reducing stand densities, reducing ladder fuels associated with the ingrowth of shade tolerant spices, and increase size class diversity across the landscape reduces fuels and the risk of larger and/or higher severity wildfires. See the Fire and Fuels report for more details (PF-FIRE-001).

Effect of the Site-Specific Forest Plan Amendment on Old Growth

The proposed site-specific Forest Plan amendment is necessary for old growth stands to be consistently identified and managed using measurable and repeatable criteria as defined in Green et al (1992, errata corrected 2011). The habitat type specific definitions of old growth, as well as the removal of the 40-acre Forest Plan standard limitation, is more inclusive, resulting in an improved method for identifying old growth in all forest types and of all stand sizes. With the new habitat type based definitions, more stands, and a greater variety of stands will meet the old growth minimum standards than would have with the original generic Forest Plan definition, in the Mud Creek project area. This amendment provides a better foundation to meet the purpose and need of the project, meet the Forest Plan goals and objects, meet the 2012 Planning Rule requirements, and maintain and manage old growth in the Mud Creek project area.

Effect of Treatment Activities on Old Growth

Vegetation management treatments will be used to improve the resilience of old growth stands by reducing competition, improving species composition, and reducing fuels especially in the drier forest types such as those most commonly found within the Mud Creek project area. To maintain or restore old growth character within existing old growth, site-specific treatments will be implemented to increase resiliency and resistance to disturbances such as insects, disease, and fire.

Treatments including commercial harvest utilizing improvement cuts, group tree and single-tree selection cuts, or non-commercial stand improvement thinning will be used to reduce competition and improve species composition while retaining the old growth characteristics as defined by Green et al (1992, errata corrected 2011) for each site-specific habitat type. Indirectly, the removal of competing in-growth will improve the old growth stands resilience to future fire and insect disturbances compared to existing conditions.

During scoping, some commenters expressed a desire to see only non-commercial or fire only treatments in old growth. In many cases, non-commercial treatments or fire alone will not effectively or safely reduce competition and stand density enough to increase old growth stand resistance and resiliency to insects, disease, and fire. Non-commercial, hand crew based, treatments are often limited to removing 8-inch DBH trees. This alone does not remove the trees greater than 8 inches DBH that are often growing under and within the crowns of the old growth trees. This also does not lower stand densities to reduce the risk and ease of spread of insects, disease, and wildfire. Finally, this does not often restore stand conditions that allow fire to naturally burn on the ground, at low intensity, resulting in a low severity fire.

Historically frequent low intensity fire kept forest floor litter from accumulating however fire exclusion has led to an accumulation of deep duff mounds around the base of these old ponderosa pine. Without taking extra precautions, burning duff mounds can damage the cambium layer and extended heat can damage the fine roots that can lead to mortality (Hood, 2010). Raking and the removal of down woody debris from the base of old growth trees will be performed on a site-specific basis, as identified in the silvicultural prescription, where duff mounds exceed 5 – 6 inches in depth prior to prescribed burning.

The Bitterroot National Forest has ongoing monitoring in old growth stands in the Como FHP project to identify any effects related to the mechanical harvest and prescribed fire treatment intended to increase resilience in old growth and mature stands. Approximately 76 acres of old growth were treated to improve stand conditions. To date, control plots (approximately 30 acres) and harvest plots have been measured before harvest and post-harvest. Prescribed burning is planned in the near future and continued monitoring will follow. Old growth monitoring plots are also scheduled for the Gold Butterfly project and will continue to be monitored following treatment. This monitoring will allow the Forest to assess how management activities or lack of, affect old growth characteristics and desired conditions over time. The monitoring on these two projects will be applied across the Bitterroot National Forest including the Mud Creek project.

Effects of Treatment Activities on Climate and Carbon

The proposed action addresses Halofsky's (2018) recommended strategies to increase landscape resilience to disturbances including climate change. At the stand level, treatments are designed to manage for the most drought and fire tolerant species in each forest type, reduce stand densities, reduce the amount of shade tolerant ingrowth, and increase genetic diversity based on site-specific conditions. At the landscape scale, treatments will increase structural diversity and size class diversity across the project area reducing the continuity of fuels, as well as reducing the insect and disease host species and the associated size class and structure. Treatments in the high elevation cold forests will focus on reducing the risk of fire, insects, and disease for species such as whitebark pine that are at a greater risk to climate change.

While the Mud Creek project area is by far too small to measure global greenhouse gas emissions, the treatments proposed are designed to improve landscape resilience to fire, insects, and disease. Reducing the risk of large wildfires, the largest source of carbon emissions (Figure 12), the proposed action is lowering the potential for increased emissions. Additionally, the establishment of new and vigorously growing age-classes will improve carbon stores (Birdsey et al, 2019).

Cumulative Effects

Past, Present, and Reasonably Foreseeable Activities Relevant to Cumulative Effects Analysis

Cumulative effects result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions. To contribute to cumulative effects, the effects of past, present, and foreseeable future actions must overlap in time and space.

The effects of past management are considered until those effects are no longer discernable. Existing vegetation conditions described at the beginning of this report reflect past timber harvest including terracing, Native American burning, naturally ignited wildfires, fire suppression, terraced plantations, and other activities that influenced forested vegetation in the project area. See Chapter 3 of the Environmental Assessment for the list of past activities that occurred in the Mud Creek project area and the list of ongoing and future activities that overlap in time and space. The past activities list is not exhaustive due to the degradation in the quality of record-keeping the further back in time the Forest Service's activity database (FACTS) is queried. See the Mud Creek Cumulative Effects Activities List (PF-SILV-007).

The proposed action will influence select locations within the project area through the implementation of commercial harvest, non-commercial treatments, and prescribed fire. These activities will effect and improve species composition, reduce stand densities, promote desirable stand structure, and increase age-class and size-class diversity across the landscape. Effects of these Mud Creek treatments are expected to last 1-20 years for short terms effects and up to 50 year for long term effects. Due to changes in vegetation conditions over time such as regeneration, growth, mortality, and natural disturbance processes, vegetation effects beyond 50 years become less reliable.

Other projects that potentially overlap in time and space include:

- The Upper Nez Perce Landscape Ecoburn project, implementing areas of prescribed fire within the 15,755 acre project area. This project overlaps with the Mud Creek project by 2,938 acres in the upper Little West Fork drainage. This prescribed burn will reintroduce fire to the landscape reducing the accumulation of fuels, reducing ladder fuels, favoring fire-tolerant species, thinning stands, and creating desirable openings.
- The Piquett Creek project, covering 5,800 acres adjacent to Mud Creek project area. Similar to Mud Creek, the proposed treatments will improve species composition, lower stand densities, promoted desirable stand structure, and increase age-call and size-class diversity across the project area through the implementation of commercial, non-commercial and prescribed fire treatments.
- Ongoing stand improvement hand thinning and slashing for fuels reduction.
- Other potential and unplanned events such as wildfire.

With the exception of potential spread of fire outside treatment boundaries (discussed in the Fire and Fuels section), the Mud Creek project treatment unit direct effects do not have the potential to affect forest vegetation outside the boundaries of the localized treatment areas. However, the indirect effects of the treatments, combined with the other adjacent and intermixed planned activities, collectively and synergistically increase the treated stand's and the greater landscape's resiliency to fire, insects and disease. The treatments break up the landscape and change the way fire is able to spread across a large area. The beneficial change in species composition to feature early seral species, the reduction in stand densities to more site-appropriate densities, the modification in canopy layers reducing ladder fuels, and the increase in age-class diversity, strategically located in treatment units across the project area, all work together and offer a greater combined landscape resilience to natural disturbances. These changes in stand characteristics also increase the resilience in old growth stands and increase the landscape's ability to cope with changing climates. These treatments reduce the risk of fire, insects and disease as well as increase the ecosystem's ability to bounce back after disturbance. It is impossible to estimate the spatial extent of the increased resilience, but the Mud Creek project contributes to an overall cumulative increase in landscape resilience to natural disturbances within and beyond the project boundary for approximately 20 to 50 years.

Summary

In summary, the proposed action would trend the landscape towards desired conditions improving landscape resilience to natural disturbances such as insects, disease, fire, and drought (Figure 24). Every acre treated designed to improve species composition, stand density, stand structure, and creates size class diversity across the landscape will collectively improve the Mud Creek project area's resiliency to disturbances. The purpose and need are met by:

- Increasing the amount of early seral species (fire tolerant species) on the landscape and restoring species compositions typical of functioning fire dependent ecosystems.

- Reducing stand density through commercial and non-commercial treatments to densities that promote tree health and vigor and enhance the tree's natural defenses to insects and disease. Lower stand densities reduce the ease of spread of insects, disease, and fire.

- Improving stand structure by reducing the ingrowth of shade tolerant species, creating growing conditions for uneven-aged stands to thrive featuring horizontally spread out age classes. Reducing the number of canopy layers reduces the spread of insects and disease as well as reduces the ladder fuels and the risk of stand replacing fires.

- Increasing size class diversity across the landscape by establishing stands of seedlings and saplings, managing for uneven-aged ponderosa pine, and creating conditions that support current and future development of mature, old trees.

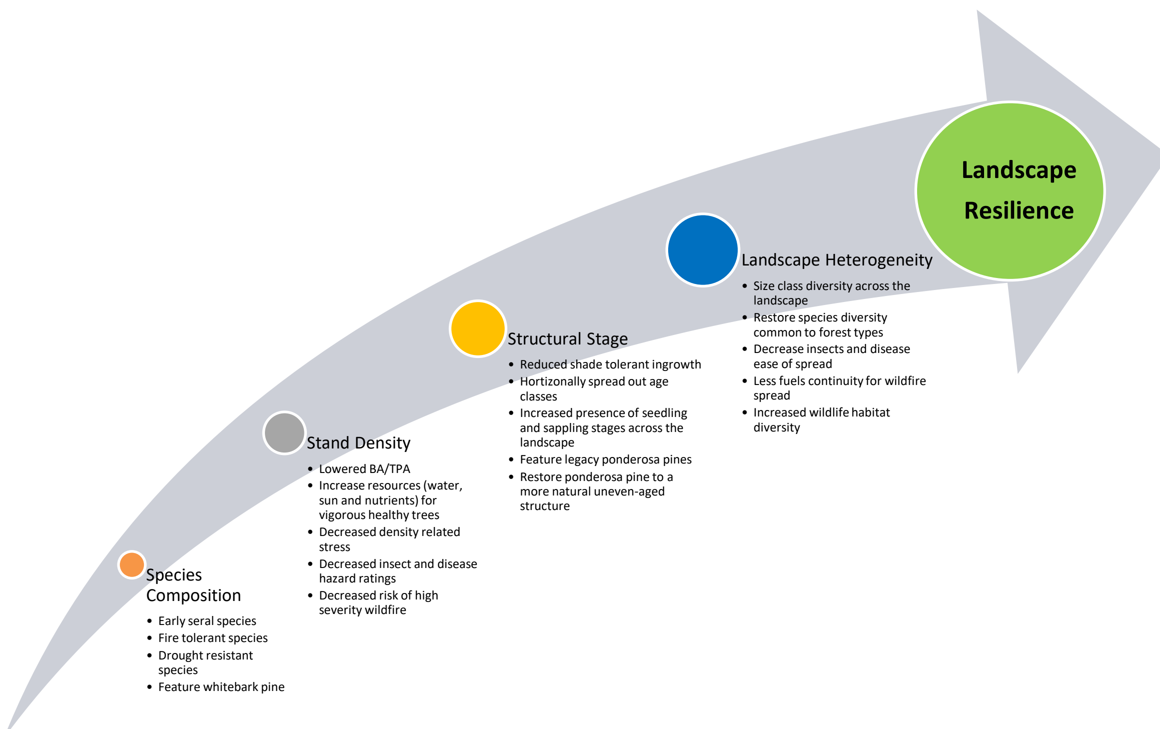


Figure 24: An improvement in forest resiliency at the landscape scale

Compliance with Forest and Other Relevant Laws, Regulations, Policies, and Plans

Regulatory Framework

The regulatory framework that the project is conducted under is as follows.

Forest Plan

Management Area and Goals

Manage Area 1: Emphasize timber management, livestock and big game forage production, and access for roaded dispersed recreation activities and mineral exploration. Assure minimum levels for visual quality, old growth, and habitat for other wildlife species.

Management Area 2: Optimize elk winter ranger habitat using timber management practices. Emphasize access for mineral exploration and roaded dispersed recreation activities. Provide moderate levels of visual quality, old growth, habitat for other wildlife species, and livestock forage.

Management Area 3A: Maintain the partial retention visual quality objective and manage timber. Emphasize roaded dispersed recreation activities, old growth, and big game cover. Provide moderate levels of timber, livestock forage, big game forage, and access for mineral exploration.

Management Area 5: Emphasize motorized and non-motorized semi-primitive recreation activities and elk security. Manage big game winter range to maintain and enhance big game habitat. Manage existing road corridors to provide recreation access.

Management Area 8A: Manage at the minimum level, but protect timber, soil, water, recreation, range, and wildlife resources on adjacent management areas. Maintain existing uses and facilities.

Forest Service Manuals and Handbooks

Forest Service Manual 2020 provides direction on managing for ecological restoration and resilience. It cites nineteen principal statutes and five executive orders that provide the authority to restore National Forest System lands. The aim is to re-establish and retain the ecological resilience of National Forest System lands and associated resources to achieve sustainable management and provide a broad range of ecosystem services. Healthy, resilient landscapes would have a greater capacity to survive natural disturbances and large scale threats to sustainability, especially under changing and uncertain future environmental conditions, such as those driven by climate change and increasing human uses.

Forest Service Manual 2470 provides broad policy guidance for silvicultural practices on the national and regional levels. Sections pertinent to this proposal include harvest cutting, reforestation, timber stand improvement, sale area improvement deposits, examinations, prescriptions and evaluations, stocking guides, and growth projections. Regional supplements include procedures for exceeding opening size limitations, and reforestation and timber stand improvement policies.

Four handbooks provide even greater detail than the manuals for their specific area of concern. They include the Silvicultural Practices Handbook (Forest Service Handbook 2409.17), Reforestation Handbook (Forest Service Handbook 2409.26b), Seed Handbook (Forest Service Handbook 2409.26f), Knutson-Vandenburg Fund Handbook (Forest Service Handbook 2409.19). The Timber Management Control Handbook (Forest Service Handbook 2409.21e) covers the timber resource information system. All handbooks contain large sections of Regional supplements.

Forest Service Manual 2370, Section 2471.1, Region 1 Supplement 2400-2016-1 generally limits the size of harvest openings to 40 acres or less. To exceed this size, Regional Forester approval is required except where natural catastrophic events (such as fire, windstorms, or insects and disease attacks) have occurred. Forest Service Manual 2471.1 (R1 Supplement 2400-2001-2) requires a 60-day public notice and Regional Forest approval for even-aged regeneration harvest openings exceeding 40 acres.

National Laws/Regulations

Basic authority for silvicultural practices on National Forest System lands is contained in the following acts:

1. Organic Administration Act of 1897 (30 Stat. 34, as supplemented and amended; 16 U.S.C. 473-478), that states the purpose of the national forests, and directs its control and administration to be in accord with such purpose, that is, “No national forest shall be established, except to improve and protect the forest within the boundaries, or for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States.”

2. Knutson-Vandenberg Act of 1930 (46 Stat. 527, as amended; 16 U.S.C. 576 - 576b), authorizes the Secretary of Agriculture to "...establish forest tree nurseries and do all other things needful in preparation for planting on national forests..." and requires the "purchaser of national forest timber to make deposits of money ...to cover the cost ...of planting, sowing with tree seeds, cutting, destroying, or otherwise removing undesirable trees or other growth and protecting and improving the future productivity of renewable resources..."

3. Bankhead-Jones Farm Tenant Act of 1937 (50 Stat. 525, as amended; 7 U.S.C. 1010-1012), authorizes and directs the Secretary to "...develop a program of land conservation and land utilization, in order thereby to correct maladjustments in land use, and thus assist in controlling soil erosion, reforestation, preserving natural resources..."

4. Anderson-Mansfield Reforestation and Revegetation Act of 1949 (63 Stat. 762; 16 U.S.C. 581j-581k), states "...it is the declared policy of the Congress to accelerate and provide a continuing basis for the needed reforestation and revegetation of national forest lands and other lands under administration and control of the Forest Service of the Department of Agriculture in order to obtain the benefits hereinbefore enumerated..."

5. Granger-Thye Act of 1950 (64 Stat. 82, as amended; 16 U.S.C. 490), authorizes the Secretary of Agriculture "... where the public interest justifies, to cooperate or assist public and private agencies,...in performing work...within or near a national forest for which the administering agency, owner, or other interested party deposits...a sufficient sum to cover the total estimated cost of the work to be done for the benefit of the depositor, for administration, protection, improvement, reforestation, and such other kinds of work the Forest Service is authorized to do on lands of the United States. It also "authorizes the Secretary of Agriculture, subject to such conditions as he may prescribe, to sell forest-tree seed and nursery stock..."

6. Multiple-Use Sustained-Yield Act of 1960 (Pub. L. 86-517, 74 Stat. 215; 16 U.S.C. 528-531), authorizes and directs the Secretary of Agriculture "...to develop and administer the renewable surface resources of the national forests for multiple use and sustained yield of the several products and services obtained therefrom..."

7. Supplemental National Forest Reforestation Fund Act of 1972 (87 Stat. 242, 245, as amended; 16 U.S.C. 576c-576e), directs the Secretary of Agriculture to establish a "Supplemental National Forest Reforestation Fund."

8. Forest and Rangeland Renewable Resources Planning Act of 1974, as amended by the National Forest Management Act (NFMA) of 1976 (16 U.S.C. 1600-1614), states "it is the policy of the Congress that all forested lands in the National Forest System be maintained in appropriate forest cover with species of trees, degree of stocking, rate of growth, and conditions of stand

designed to secure the maximum benefits of multiple use sustained yield management in accordance with land management plans" and directs the Secretary of Agriculture to ensure that timber will be harvested from National Forest System lands only where there is assurance that such lands can be adequately restocked within five years after harvest. It provides for logging while recognizing "the fundamental need to protect and where appropriate, improve the quality of soil, water, and air resources." It ensures that timber will be harvested from national forest lands "only where soil, slope or other watershed conditions will not be irreversibly damaged." It also specifies that "protection is provided for streams, stream-banks, shorelines, lakes, wetlands, and other bodies of water from detrimental changes in water temperatures, blockages of watercourses, and deposits of sediment, where harvest are likely to seriously and adversely affect water conditions or fish habitat."

9. Reforestation Trust Fund, Title III - Reforestation, Recreation Boating Safety and Facilities Improvement Act of 1980 (16 U.S.C. 1606a, as amended), establishes "...in the Treasury of the United States a trust fund, to be known as the Reforestation Trust Fund..., consisting of such amounts as are transferred to the Trust Fund under Subsection (b) (1)..."

10. Healthy Forests Restoration Act (HFRA) of 2003 (16 U.S.C. at 1611-6591), provides processes for developing and implementing hazardous fuel reduction projects on certain types of "at-risk" National Forest System and Bureau of Land Management (BLM) lands, and also provides other authorities and direction to help reduce hazardous fuel and restore healthy forest and rangeland conditions on lands of all ownerships.

National Forest Management Act

The National Forest Management Act (number 8 in the list above), U.S. Public Law 94-588, 1976; is the principal law governing vegetation management treatments on National Forest System lands. Below is a further explanation of how the law affects the vegetation resource.

This project is consistent with the National Forest Management Act. Treated stands would be more resilient to insect, disease, and fire post-harvest; therefore, more likely to maintain appropriate forest cover and appropriate stocking levels than they would have been prior to treatment. Intermediate harvest units would remain stocked immediately post-harvest; units receiving regeneration harvest would be stocked within five years, this would be checked by one, three, and five-year regeneration stocking surveys.

1. Suitability for Timber Production: No timber harvest, other than salvage sales or sales to protect other multiple-use values, shall occur on lands not suited for timber production (16 USC 1604(k)).

Suitability for Timber Production 36 CFR 219. 11 (2017)

Lands identified as generally suitable for timber harvest and timber production are designated in the Forest Plan. These lands are validated at the project level. Project level suitability determinations are made during silviculture diagnosis and soil review. As a pre-cursor to the silvicultural diagnosis process, stand examinations are conducted to determine existing stand conditions, and suitability for timber production for each stand. Final suitability determinations for lands proposed for commercial timber harvest would be documented in a site-specific silviculture diagnosis and prescription, prepared or reviewed by a certified Silviculturist, in coordination with the Soil Scientist.

In addition, the Forest Plan (1987) initially determined Douglas-fir/ninebark habitat types as unsuitable from the regeneration standpoint. The assumption was that stands of Douglas-fir heavily infected with dwarf mistletoe would require clearcuts for regeneration purposes; however, the soils were too rocky to hand plant. The alternative to apply a shelterwood system and rely on natural regeneration would not be biologically acceptable since Douglas-fir regeneration, if adequate, would be infected by the Douglas-fir overstory (Bitterroot National Forest 1981). The Forest Plan Monitoring and Evaluation Report, fiscal year 2003 (USDA Forest Service 2003b) states that previous monitoring of these Douglas-fir/ninebark habitat types has determined that these sites should be classified as suitable.

All units proposed during the Implementation Phase will be on lands suitable for timber production in the Mud Creek project.

2. Timber Harvest on National Forest Lands (16 USC 1604(g)(3)(E)): A Responsible Official may authorize site-specific projects and activities to harvest timber on National Forest System lands only where:

    a. Soil, slope, or other watershed conditions will not be irreversibly damaged (16 USC 1604(g)(3)(E)(i)).

       Watershed conditions have been evaluated and it has been determined that with design criteria they will not be irreversibly damaged by full implementation of this project. Refer to the Implementation Plan and the Soils and Watershed reports.

    b. There is assurance that the lands can be adequately restocked within five years after final regeneration harvest (16 USC 1604(g)(3)(E)(ii)).

       Reference regeneration timeframe report on past planting success rates. Stands prescribed for regeneration harvest will regenerate naturally or artificially and will be inspected for acceptable stocking at years 1, 3 and 5 following harvest.

    c. Protection is provided for streams, streambanks, shorelines, lakes, wetlands, and other bodies of water from detrimental changes in water temperatures, blockages of water courses, and deposits of sediment, where harvests are likely to seriously and adversely affect water conditions or fish habitat (16 USC 1604(g)(3)(E)(iii)).

       Refer to the project file under hydrology and fisheries analysis for project specific protection requirements and rules and laws applicable to this resource.

    d. The harvesting system to be used is not selected primarily because it will give the greatest dollar return or the greatest unit output of timber (16 USC 1604(g)(3)(E)(iv)).

       Selection of harvest system is based site specific conditions and the most effective system to meet the project's purpose and need.

3. Clearcutting and Even-aged Management (16 USC 1604(g)(3)(F)): Insure that clearcutting, seed tree cutting, shelterwood cutting, and other cuts designed to regenerate an even aged stand of timber will be used as a cutting method on National Forest System lands only where:

a. For clearcutting, it is determined to be the optimum method, and for other such cuts it is determined to be appropriate, to meet the objectives and requirements of the relevant land management plan (16 USC 1604(g)(3)(F)(i)).

   Units that are proposed for regeneration harvest will increase stand and landscape resilience to insects, disease and restore natural mean patch size and patch size natural range of variability typical for the forest type and the associated fire regime.

b. The interdisciplinary review as determined by the Secretary has been completed and the potential environmental, biological, esthetic, engineering, and economic impacts on each advertised sale area have been assessed, as well as the consistency of the sale with the multiple use of the general area (16 USC 1604(g)(3)(F)(ii)).

   Refer to the project file and other resource reports for additional analysis.

c. Cut blocks, patches, or strips are shaped and blended to the extent practicable with the natural terrain (16 USC 1604(g)(3)(F)(iii)).

   The harvest units will be blended and feathered to avoid straight edges and are not prescribed to be uniform in shape, size, or arrangement.

d. Cuts are carried out according to the maximum size limit requirements for areas to be cut during one harvest operation, provided, that such limits shall not apply to the size of areas harvested as a result of natural catastrophic conditions such as fire, insect and disease attack, or windstorm (FSM 2470 R1 supplement 2400-2016-1, 16 USC 1604 (g)(3)(F)(iv)), (36 CFR 219.11(d)(4 (i)-(ii)).

   The size of cuts are based on stand conditions, insect and disease activity, and natural mean patch size and patch size natural range of variability typical for the forest type for each proposed cut. Regional Forester approval will be sought in order to follow through with the creation of the proposed openings expected to exceed 40 acres.

e. Such cuts are carried out in a manner consistent with the protection of soil, watershed, fish, wildlife, recreation, and esthetic resources, and the regeneration of the timber resource (16 USC 1604(g)(3)(F)(v)).

   In areas where regeneration harvest will be proposed, it will be determined to be the most appropriate harvest technique to meet the project purpose and need. All proposed activities have been reviewed by the interdisciplinary team. Refer to the project file and other resource reports for further analysis.

f. Stands of trees are harvested according to requirements for culmination of mean annual increment of growth (16 USC 1604(m)).

   Because of age and/or reductions in periodic and annual volume accretion rates due to reduced growth and mortality from insects and diseases all of the stands proposed for regeneration harvest have met the culmination of mean annual increment (CMAI) requirement. In addition, harvesting and regenerating these stands are intended to increase the amount of seedling/sapling size class while decreasing the Douglas-fir and/or lodgepole pine forest types and medium-size class. This would trend these measures of forest resilience on the landscape within the project area toward the desired conditions.

The Mud Creek Project is in compliance with federal law, forest plan standards, and Forest Service Handbook and Manual direction. The Mud Creek project is in compliance with and consistent with the Forest Plan standards and objectives.

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